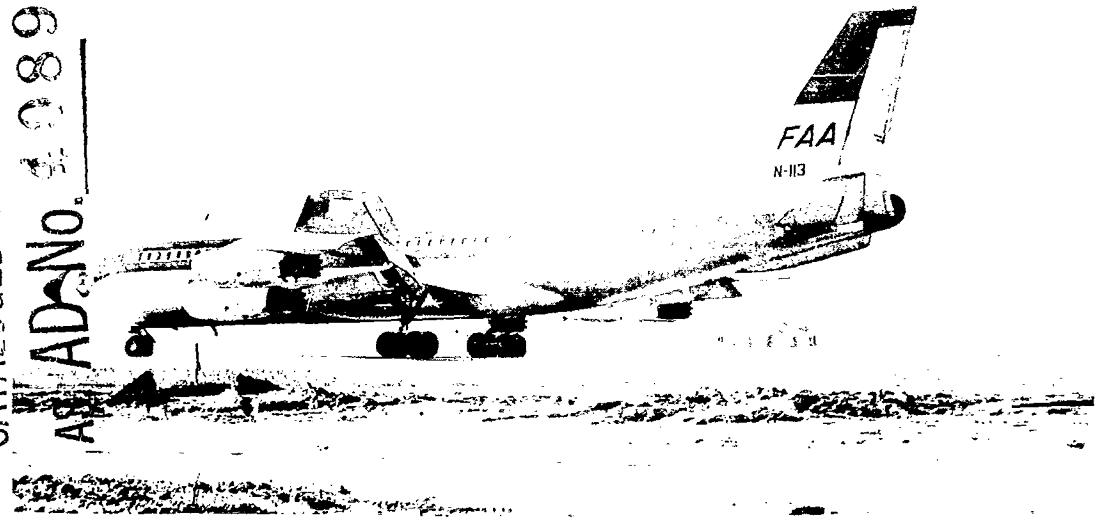


FINAL REPORT, CONTRACT FAA ARDS-437

DEVELOPMENT OF MODEL 3500 ARRESTING GEAR AND CONTINUED DEVELOPMENT OF SPRING HOOK FOR COMMERCIAL AIRCRAFT

M-788
PART II
January 1963

Prepared for

FEDERAL AVIATION AGENCY
SYSTEMS RESEARCH AND DEVELOPMENT SERVICE

By

ALL AMERICAN ENGINEERING COMPANY
WILMINGTON, DELAWARE

FINAL REPORT, CONTRACT FAA ARDS-437

DEVELOPMENT OF MODEL 3500 ARRESTING GEAR AND CONTINUED DEVELOPMENT OF SPRING HOOK FOR COMMERCIAL AIRCRAFT

M-788
January 1963

PART II

This report has been prepared by All American Engineering Company for the Systems Research and Development Service, Federal Aviation Agency, under Contract No. FAA ARDS-437. The contents of this report reflect the views of the contractor, who is responsible for the facts and the accuracy of the data presented herein, and do not necessarily reflect the official views or policy of the FAA.

ALL AMERICAN ENGINEERING COMPANY
WILMINGTON 99, DELAWARE

Prepared by: A. Russo, Jr.

Checked by: M. C. Wardle

Approved by: B. J. Salvadori

TABLE OF CONTENTS

INTRODUCTION

Part II of this report is the presentation of the results and interpretation of strain data accumulated on the hook equipped Boeing 720-027, N-113 during the Model 3500 Arresting Gear tests at NAFEC, Atlantic City, New Jersey.

The instrumentation used to gather the data used herein is described in Part I of this report.

Calculations on the applied nose landing gear loads and cross-wind fuselage stresses are included.

Nose landing gear deflections were recorded but not tabularized or utilized in the calculations of loads.

DISCUSSION AND DESCRIPTION

The FAA Boeing 720 Dynamic arresting gear test was conducted from October 19, 1962 to October 30, 1962 at the National Aviation Facility Experimental Center test site at Atlantic City, New Jersey.

Stress instrumentation used during the test were strain gages to obtain fuselage bending and cap stresses along with the tail hook shank stresses. Strain gage location and significance is described on pages 12 and 13 . Figure 2 on page 14 shows the gage locations.

A metalurgical study was made of the hook shank which was yielded during the arrestment tests. Specimens were obtained from the yielded area and from a similar area of low stress. The stress-strain curves drawn for these specimens showed that strain-hardening took place. The increase in the yield strength is due to high loads which are a combination of bending, tension, and hook dynamic behavior. By raising the elastic limits, the fatigue strength of the deformed section increases for a given number of load cycles, but ultimately reduces its fatigue life.

The engaging velocities experienced were 78.4 to 135.6 knots and gross weights of 135,000, 175,000, and 220,000 pounds were used. Off center shots were 40 ft. at the lower gross weight and 20, 40, and 60 ft. for the maximum gross weight. One test run for the 175,000 pound gross weight with an engaging velocity of 96.4 knots and 10 ft. off center was conducted. Engaging velocities, aircraft runout, distance from centerline, hook loads, hook angles, and aircraft configuration for the actual gross weights can be found on page 15 .

Total combined effect of keel beam stresses obtained during arrestment and deadload stresses for the 135,000, 175,000, and 220,000 pound gross weight conditions are tabulated on pages 23 to 25 . The deadload stresses are calculated on page 25 .

An analysis for the nose gear load and an example calculation using run 25 for the Boeing 720 airplane during arrestment are on pages 26 to 35 . Also a free body diagram of the forces acting on the aircraft for this condition is on page 36 . Justification for using run 25 as an example is explained on page 37 .

The cross wind stresses in the fuselage at balance station 887 due to cantilever action are small, reference page 39 .

Two curves were plotted on pages 42 and 43 of hook load vs stress for strain gage 7, the steel hook attachment fitting, forward of production station 960. It is to be noted that for high hook loads, the stresses are starting to exceed the limits from static test load condition III (Reference: b.). Since the material is steel, these stresses are well below the limit design stress.

All the other gages on the fuselage which were read and summarized on Page 2 have low stresses. The stresses (Gage S17 and S18) on the hook shank have no general trend of hook load vs stress because of the dynamic effect during arrestment. These stresses are well under the design limit stress.

The appendix consists of two parts:

(1) Appendix C, Interpretation of the data obtained from the Boeing 720 and 707 hooks tested at Swarthmore College, Pennsylvania.

(2) Appendix D, Strain gage data reduced during the NAFEC tests.

SUMMARY

The fuselage stresses, fuselage accelerations and engine accelerations obtained on the FAA Boeing 727-027, N-113 during arrestments into the Model 3500 Arresting Gear at speeds through 135.6 knots and gross weights through 220,000 pounds were within safe working levels.

A summary of stresses as obtained by strain measurement are shown on pages 5 through 9.

PREPARED BY ______ **ALL-AMERICAN ENGINEERING CO.** PAGE 5

CHECKED BY ______ DU PONT AIRPORT - WILMINGTON, DELAWARE MODEL NO. ______

DATE ______ Summary of Gage Stresses REPORT NO. ______

Project Run No.	Engaging Velocity	Gross Wt.	Distance From ℄	S7	S8	S9	S10	S11	S12
	knots	lbs	ft.	psi	psi	psi	psi	psi	psi
1	80.8	135000	on ℄	12600	0	0	-3900	5400	3260
2	120.8	"	"	29900	16750	0	12600	8550	---
3	106.5	"	"	22500	6020	0	-8560	7210	6180
4	119.2	"	"	28900	—	—	-8750	9080	4860
5	128.2	"	"	31100	5030	-3680	-13700	11420	7900
6	135.6	"	"	36000	53700	0	-14020	11030	9300
7	78.4	"	40	9150	1900	0	-3640	3620	2970
8	100.1	"	"	19320	3310	0	-8030	6680	4610
9	116.2	"	"	26800	4130	0	-10400	8860	6900
10	130.2	"	"	33500	5550	711	-10700	7750	8100
10a	Braking	175000		-4350	1640	2860	2350	-8380	-7120
11	85.5	220000	on ℄	21700	1970	0.	-8200	6780	5510
12	101.1	"	"	28800	2950	0	-10900	8500	6320
13	114.7	"	"	39200	2950	0	-15100	10900	9150
14	123.0	"	"	42000	4050	0	-16000	12500	10400
15	129.8	"	"	48800	4100	0	-19600	13200	12500
16	78.5	"	20	13900	2620	0	-7100	6620	5100
17	104.2	"	"	31602	3320	0	-12100	9200	8220
18	121.0	"	"	37700	3500	0	-15000	10500	9150
19	79.5	"	40	17202	1670	0	-6900	6620	7300
20	102.4	"	"	29400	2970	0	-11950	9260	7670
21	127.4	"	"	44200	3580	0	-16100	12000	6820
22	94.0	"	60	25000	2560	0	-9450	7030	5360
23	106.8	"	"	32200	3070	0	-8320	9600	7520
24	115.4	"	"	36100	3070	0	-6380	10150	8950
25	126.0	"	"	45600	+1700	+2360	2740	-9150	3940
26	116.0	"	40	33800	1710	0	2740	-5920	9300
27	123.2	"	20	42800	2560	0	1830	-6460	9300
28	96.4	175000	10	6430	0	0	4030	-3700	3740

PREPARED BY

CHECKED BY

DATE

ALL-AMERICAN ENGINEERING CO.

DU PONT AIRPORT - WILMINGTON, DELAWARE

Summary of Gage Stresses

MODEL NO.

REPORT NO.

Project Run No.	S13	S14	S15	S16	S17	S18	S19	S21	S22
	psi	psi	psi	psi	psi	psi	psi	psi	psi
1	—	2460	5600	—	-100000	—	NR	NR	NR
2	—	5250	—	—	-106000	-61000	3160	-1650	0
3	—	4240	5480	0	-108000	—	1280	1650	—
4	—	5160	6690	—	-124000	—	-1170	1650	0
5	—	5550	7390	—	-132000	N.R.	1451	1385	0
6	11920	6620	9500	—	-140000	N.R.	2030	2090	1780
7	4130	1750	3370	—	-103000	N.R.	0	0	0
8	8220	3990	17300	—	-102800	N.R	NR	NR	NR
9	10280	5200	7000	—	-113500	N.R.	1415	-2510	0
10	12500	6100	8050	—	-155000	N.R.	2450	1750	0
10a	-12000	-4050	-6700	—	0	N.R.	-206	1135	1840
11	8820	9270	7700	—	-105000	-53000	0	0	0
12	10100	5250	7350	—	-87500	-46100	1690	0	0
13	8850	7200	8020	—	-83500	-59500	1670	4620	0
14	14800	8250	11400	—	-80800	-53800	2500	0	9550
15	16000	8520	10600	—	-89500	-72000	2690	4950	0
16	8000	3600	6450	—	-90000	-60600	1055	0	0
17	10900	6000	9200	—	-85200	-78000	2580	1680	0
18	13500	7200	9500	—	-95000	-58800	1710	1190	0
19	7820	3700	6330	—	-96400	-60700	1070	0	0
20	11200	5720	6810	—	-104000	-81200	1055	0	0
21	6400	3040	12000	—	-91400	-56000	2120	0	0
22	8530	3930	6520	—	N.G	-60500	1057	1150	0
23	11950	5730	9260	—	N.G.	-60500	3160	-1192	0
24	12400	6630	9950	—	N.G.	-57800	2110	1192	0
25	11750	7180	10300	—	N.G.	-62400	2110	478	0
26	12400	6630	9950	—	-87700	-47700	1660	0	0
27	4700	4880	6630	—	-156000	-68800	5110	1328	0
28	4600	2270	3315	—	-119000	-75300	1040	442	0

PREPARED BY

CHECKED BY

DATE

ALL-AMERICAN ENGINEERING CO.

DU PONT AIRPORT - WILMINGTON, DELAWARE

MODEL NO.

REPORT NO.

Project Run No.	S23	S26	S27	S28	S29	S30	S31	S32	S33
	psi	psi	psi	psi	psi	psi	psi	psi	psi
1	N.R	N.R	N.R	N.R	N.R	N.R	N.R	N.R	N.R
2	2660	5830	±5520	6860	4470	0	-10000	-2430	0
3	2330	3520	4940	5680	4870	—	-6700	±2420	2400
4	0	3640	6720	6100	5510	0	4170	-1160	3140
5	2540	4180	6350	8480	7080	4570	4950	-2320	2590
6	4340	5760	3350	3420	6840	7750	-11300	-2190	3370
7	0	0	-1960	2200	1960	0	0	0	0
8	NR	NR	NR	NR	NR	NR	NR	NR	NR
9	1420	4300	6850	7200	6500	6550	-9550	-2850	4450
10	2500	4650	7850	9500	7450	12000	-1650	-2560	4050
10a	7310	-1595	-7480	-8170	-7480	-2390	-10700	-6810	-6480
11	0	1840	-2960	2570	2250	0	0	-3430	2400
12	0	2870	7680	7010	6350	0	-1240	-3320	2220
13	0	5450	8830	8900	8680	3470	-14050	-8600	3550
14	11350	6470	9930	11650	9690	6530	-13700	-2650	4280
15	0	6250	10900	11650	10150	4120	-16800	-1492	3900
16	2000	2120	3240	5350	0	975	-12700	-3540	2880
17	0	5300	7400	8500	8950	3410	-11900	-3700	—
18	0	3580	5280	9600	6660	3320	-17000	-4870	3320
19	1900	2500	3860	5550	0	985	-5080	-3430	3050
20	-760	7280	-950	2840	4720	12500	-9170	-2610	2270
21	0	4160	4750	6630	10650	3940	-18200	-6580	5300
22	0	3760	5350	5900	8860	2630	-8640	-4700	2280
23	0	5620	7440	8970	6520	3650	-6980	-6080	2850
24	0	6250	6100	8820	8890	3980	-11620	-5420	4020
25	0	6670	9530	10450	11850	3320	-3330	-3380	4020
26	1870	6650	8580	9900	8890	3900	-9320	-5420	4020
27	0	6250	8580	8250	7700	3900	-5930	-5420	2870
28	0	0	1910	2360	0	0	0	-2540	1910

PREPARED BY ____________ CHECKED BY ____________ DATE ____________

ALL-AMERICAN ENGINEERING CO.

DU PONT AIRPORT - WILMINGTON, DELAWARE

MODEL NO. ____________
REPORT NO. ____________

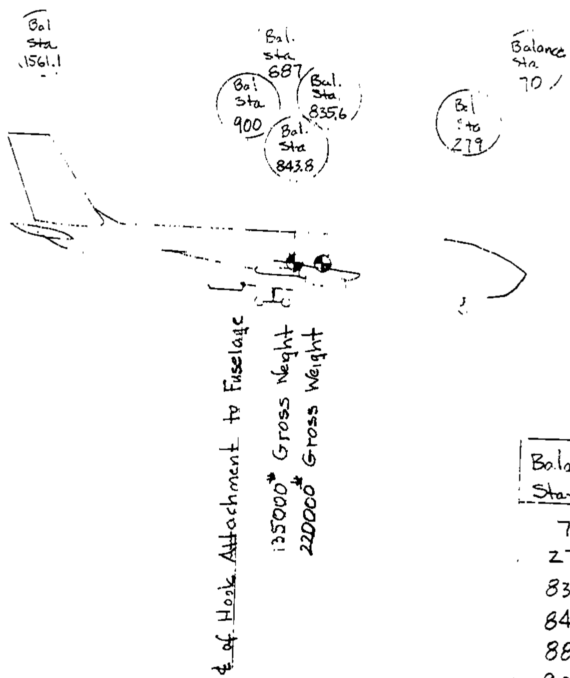
Project Run No	S34	S35
	Pc	Pc
1	N.R	N.R.
2	N.R	N.R
3	N.R	N.R
4	N.R	N.R.
5	N.R	N.R
6	N.R	N.R
7	N.R	N.R.
8	NR	NR
9	NR	NR
10	3300	0
10A	-585	3380
11	0	0
12	1290	-496
13	990	0
14	3850	2320
15	1940	660
16	2400	-1440
17	990	1800
18	-3980	2150
19	0	1750
20	3450	1780
21	-2470	-3560
22	2470	-2850
23	-3440	-2500
24	2460	1800
25	938	0
26	—	—
27	—	—
28	—	—

Summary of Accelerations (g's)

# Project Run No.	a_x	a_{zy}	a_{zz}	a_{Ex}	a_{EY}		Engaging Velocity knots	Gross Wt lbs.	Distance From ℄ ft.
1	.31	small	—	—	—		80.8	135000	on ℄
2	1.08	small	—	—	—		120.8	"	"
3	.82	small	—	—	—		106.5	"	"
4	.91	.12	—	—	—		119.2	"	"
5	N.R	N.R	—	—	—		128.2	"	"
6	1.07	small	—	—	—		135.6	"	"
7	.37	.26	—	—	—		78.4	"	40
8	.62	small	—	—	—		100.1	"	"
9	.81	.44	—	—	—		116.2	"	"
* 10	1.03	.41	—	—			130.2	"	"
11	.46	small	—	.46	.36		85.5	220000	on ℄
12	.64	.14	—	.91	.12		101.1	"	"
13	.77	.23	—	.56	.30		114.7	"	"
14	.88	.22	—	.70	.30		123.0	"	"
15	.91	.15	—	.65	.58		129.8	"	"
16	.36	.15	—	.47	.37		78.5	"	20
17	.60	.23	—	.58	.30		104.2	"	"
18	.77	.19	—	.64	.22		121.0	"	"
19	.45	.15	—	.46	.22		79.5	"	40
20	.51	.15	—	.47	.30		102.4	"	"
21	.87	.37	—	.93	.44		127.4	"	"
22	.51	.11	—	.65	.22		94	"	60
23	.60	.37	—	.93	.37		106.8	"	"
24	.70	—	.34	1.03	.37		115.4	"	"
25	.85	—	.40	1.12	.44		126.0	"	"
26	.84	—	.16	.84	.29		116.0	"	40
27	.88	—	.40	.93	.45		123.2	"	20
28	.86	—	.47	1.21	.87		96.4	175000	10
* 10a	1.2	.40	—	1.30	.60	Braking	Hard Braking		
10a	.7	.40	—	.90	.60		Normal Landing		
Bal Sta = 610	a_x = Fwd. Acceleration on Fuselage ℄								
Bal Sta = 1306	a_{zy} = Lateral Acceleration on Fuselage								
# Bal Sta = 1306	a_{zz} = Vertical Acceleration on Fuselage								
Lateral Sta = 552	a_{Ex} = Fwd. Acceleration on Outboard Engine								
Lateral Sta = 552	a_{EY} = Lateral Acceleration on Outboard Engine								

Location of Subject Material

Fig 1



Balance Station (in)	Production* Station (in)
70	130
279	339
835.6	895.6
843.8	903.8
887	947
900	960
1561.1	1621.1

* Production Station = Balance Station + 60

Strain Gage Data

Gage	Gage Location	Limit Stress* Design Cond.	Significance
S-7(s)	Stl. fitting, bottom of body	142,000 psi Cond IIIA	Max. bending + axial stress body of stl. fitting
S-8	Existing stiffener Sta 960	26,400 psi Cond. IIIA	Distribution of vertical loads from blkd. 960 to tank walls
S-9	Existing stiffener sta 960	< 26,400 psi cond. IIIA	Same as above
S-10	Top of alum. beam fwd of end vert. hole	43,300 psi cond. IIIA	Max. bend. in alum. beam
S-11	Keel, at sta. 920	16,100 psi cond. IIIA	Monitor keel load build-up; should be half of max. load
S-12	Tension strap	42,900 psi cond IIIA	Avg. tensile stress in strap
S-13	℄ tee flange at sta 865	0 All cond's	Indicate load remaining in floor at sta 865.
S-14	Skin in floor aft of load transfer section sta 865	0 All cond's	Indicate load remaining in floor at sta 865
S-15	Keel at sta 865	32,200 psi Cond IIIA	Should have large % of aft loading
S-16 (s), S-17 (s)	Upper hook shank 4½" from hole	64,000 psi, 99,000 psi	S16+S17 = Axial stress (Hook Load), S16-S17 = Bend stress

* Ref. b.

Strain Gage Data - Cont'd

S-18(S)	Hook pt. above weld - one side only	163 000 psi	Max. surface (Upper Side) stress
S-19	Tension strap, sta 930 33" up	———	Distributation of load into tank walls from 930 blkd.
S-21	Stringer, aft face of sta 960; ℄ at W.L. 185	7700 psi Cond III A	Comp. stress in stringer. Distributed load to shear panels & then to tank walls
S-22	Peripheral angle, Bottom of sta 960, 45° from vert.	———	Side load distributed into sta 960 blkd.
S-23	Forged side member blkd. sta 960, 85° from vert.	———	Same as above
S-26	On vert. web of ℄ T	———	Determine stress distribution fwd of hook attach. fitting (sta 960)
S-27	On vert. web of ℄ T	———	Same as above
S-28	On vert. web of keel beam	———	Same as above
S-29	On vert. web of keel beam	———	Same as above
S-30	On vert. web of keel beam	———	Determine stress distribution between sta 930 & 960
S-31	Near ℄ of airplane on extreme fiber of hat section @ ⊔┌ tip	———	Determine stress distribution aft of hook attach. fitting (sta 960)
S-32	On vert. web of keel beam	———	Same as above
S-33	On vert. web of keel beam	———	Determine stress distribution between sta 930 & 960
S-34	Upper flange floor beam sta 1020	———	Indicate stress due to hook shank hitting bottom of fuselage.
S-35	Lower flange floor beam sta 1020	———	Same as above

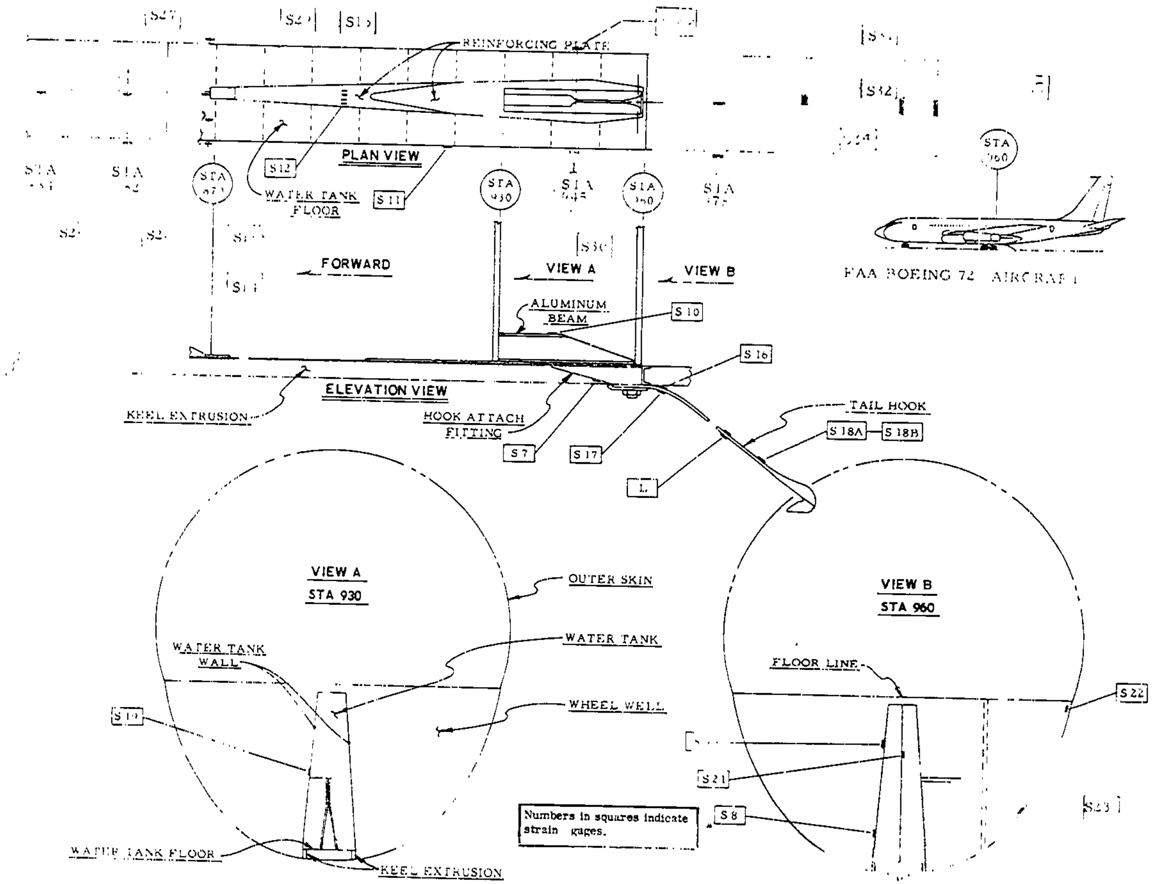


Figure 2 Strain Gage Locations

MODEL 3500 A/G TESTS AT NAFEC, ATLANTIC CITY, NEW JERSEY

Tabulated Load Data

Project Run No.	Peak Dynamic Hook Load (lbs)	Peak Hydraulic Hook Load (lbs)	Hook Angle at Peak Hydraulic Load (Deg.)	Max. Hook Angle (Deg.)	Hook Load at Max. Angle (lbs.)	Engaging Velocity (knots)	Actual Aircraft Weight (lbs)	Aircraft Run out (ft.)	Distance From ℄ (ft.)	Aircraft Configuration
1	46,000	66200	1.4	6.1	41,000	80.8	135,000	1365	0	30° flap, C.G. 22% MAC, stabilizer trim 2 units nose up
2	N.R	N.R.	N.R.	3.5	N.R.	120.8	134400	1355	0	"
3	72,000	96,300	4.3	5.0	56200	106.5	135808	1405	0	"
4	84500	118,000	.9	6.2	68,500	119.2	135,845	1450	0	"
5	N.R.	N.R	N.R	N.R.	N.R.	128.2	136,045	1435	0	"
6	[illegible]7,100	135,000	.5	4.1	71,200	135.6	135,610	1445	0	"
7	43,000	51,500	1.4	12.5	10,300	76.2	135,687	1310	40	"
8	68,800	75,900	4.0	10.3	50,600	100.1	135,340	1400	40	"
9	83,000	102,700	1.8	13.0	56,600	116.2	135,945	1455	40	"
10	102,900	132,000	.5	13.4	40,200	130.2	136,200	1465	40	"
*10a	Braking									"
11	52,400	83,900	.5	3.0	20,800	85.5	220,575	1545	0	30° flap, C.G. 19.8%, stabilizer trim 2 units nose up
12	70,300	113,900	1.0	4.5	62,900	101.1	219,865	1560	0	"
13	91,000	150,900	.5	5.9	75,700	114.7	219,860	1590	0	"
14	102,300	162,000	.5	4.6	92,500	123.0	220,000	1625	0	"
15	107,800	189,000	.9	4.1	91,400	129.8	219,800	1640	0	"
16	43,100	68,400	1.4	9.5	19,100	78.5	220,180	1620	20	"
17	73,400	122,800	0	8.6	21,500	104.2	219,620	1630	20	"
18	101,000	152,900	1.2	8.6	72,000	121.0	219,965	1705	20	"
19	56,400	68,900	1.8	13.0	10,300	79.5	220,170	1640	40	"
20	70,200	102,800	3.6	14.6	41,400	102.4	219,300	1675	40	"

* Purpose of run was to measure engine accelerations by use of max. brake & reverse thrust.

Tabulated Load Data - Cont'd

Project Run No.	Peak Dynamic Hook Load (lbs.)	Peak Hydraulic Hook Load (lbs.)	Hook Angle at Peak Hydraulic Load (Deg.)	Max. Hook Angle (Deg.)	Hook Load at Max. Angle (lbs)	Engaging Velocity (knots)	Actual Aircraft Weight (lbs)	Aircraft Runout (ft)	Distance From ℄ (ft)	Aircraft Configuration
21	102,800	167,900	2.0	12.4	67,600	127.4	220,850	1720	40	30° flap, C.G. 19.8%, stabilizer 2 units nose up
22	81,100	111,100	.9	19.7	14,300	94.0	220,100	1660	60	"
23	82,600	138,500	.5	13.6	12,700	106.8	220,000	1660	60	"
24	93,400	148,300	0	13.6	85,400	115.4	219,590	1655	60	"
25	111,000	183,800	0	17.6	14,500	126.0	220,400	1675	60	"
26	95,500	165,800	0	13.0	67,000	116.0	219,600	1690	40	"
27	114,300	180,500	1.7	9.6	66,100	123.2	220,000	1700	20	"
*28	47,700	———	1.6	7.7	31,800	96.4	174,000	670	10	"

* At approx. 500 ft from pendant, full brake & reverse thrust applied

KEEL BEAM STRESSES

Oscillagraph Data

PREPARED BY

ALL-AMERICAN ENGINEERING CO.

CHECKED BY

DU PONT AIRPORT – WILMINGTON, DELAWARE

DATE NOV 2 1962

135^K to 175^K LOAD *

PAGE 18

MODEL NO.

REPORT NO.

	G	K	Rc	$F_2 = K/Rc$	ΔD	$\epsilon \times 10^{-6} = F_2 \times \Delta D$	$E \times 10^6$	$S = \epsilon E$
1	S-7	2910	1.59	1830	-.01		29	-531
2	S-8	2869	1.85	1550	-.04		10.5	-652
3	S-9	2869	.43	6670	-.02		10.5	-1400
4	S-10	2867	1.65	1738	0		10.3	0
5	S-11	2869	1.65	1738	-.01			-179
6	S-12	2867	1.81	1585	-.1			-1630
7	S-13	2876	1.46	1982	-.11			-2245
8	S-14	2896	1.72	1682	-.07			-1215
9	S-15	2869	.88	3260	-.02		10.3	-672
10	—	—	—		—		—	—
11	S-17	2057	.62	3315	—		22.5	—
12	S-18		N.R.		—		—	—
13	S-19	2869	1.44	1992	-.04		10.3	-822
14	S-21	2896	1.34	2160	+.01		10.7	231
15	S-22	2869	.34	8445	-.01		10.3	-869
16	S-23		.82	3500	+.01			361
17	S-26		1.55	1850	-.03			-574
18	S-27		1.50	1912	-.09			-1772
19	S-34		.48	5980	-.07			-4320
20	S-28		1.32	2175	-.07			-1569
21	S-29	2867	1.50	1912	-.10			-1920.
22	S-30	2896	.28	10,340	-.01			-1065
23	S-31	2876	.35	8275	-.08			-6820
24	S-32	2876	1.78	1627	-.07			-1172
25	S-33	2869	1.58	1815	-.09			-1682
26	S-35	2869	.57	5045	+.03		10.3	1558

* INCREASE IN G.W. PRODUCED BY SANDBAGS AFT OF AFT LANDING GEAR.

Oscillograph Data

PREPARED BY JGW

CHECKED BY

DATE Nov 1, 1962

ALL-AMERICAN ENGINEERING CO.

DU PONT AIRPORT -- WILMINGTON, DELAWARE

175K to 220K Load *

PAGE 19

MODEL NO.

REPORT NO.

		K	R_c	$F_z = K/R_c$	ΔD	C x..	E x10	S		
1	S7	2910	.51	1830	—	-	29.0	—		
2	S8	2869	1.86	1550	-	..	10.5	—		
3	S9		44	6530	-		10.5	—		
4	S10		1.64	1750	.01	18	10.3	185		
5	S11		1.64	1750	-.04	70	↓	-720		
6	S12		1.86	1545	-.05	80		-825		
7	S13		1.45	1980	-.07	140		-1440		
8	S14		1.74	1650	-.06	19		-1020		
9	S15	2869	.85	3285	–	—	↓	–		
10			.62			–	10.3			
11	S17	2057	.63	3265			28.5			
12	S18						28.5			
13	S19	2869	1.42	[illegible]	.03	60	10.3	618		
14	S21	2896	1.36	2130	–	-	10.7	—		
15	S22	2869	.84	3430	–		10.3	–		
16	S23		1.10	2610	–		-	-		
17	S26		1.56	1840	01	18		185		
18	S27		1.50	1910	.03	57		588		
19	S34		.49	5860	–					
20	S28		1.27	2260	.03	67		640		
21	S29	2869	1.5-	1910	03	57		588		
22	S30	2896	29	9980	–			-		
23	S31	-	.46	6300	–					
24	S32		1.78	1625	—	—	—	—		
25	S33		1.60	1810	.03	54		555		
26	S35	2896	.58	5000	–		10.3	—		

* INCREASED G.W. PRODUCED BY WATER BALLAST IN CONTAINERS ON FUSELAGE FLOOR BETWEEN NOSE WHEEL AND AFT LANDING GEAR.

PREPARED BY

CHECKED BY

DATE

ALL-AMERICAN ENGINEERING CO.

DU PONT AIRPORT - WILMINGTON, DELAWARE

PAGE 20

MODEL NO.

REPORT NO.

[illegible]

Item	Weight	Sta. of Items	Sta. of Effects	Arm	$\frac{\text{Arm}^2}{12}$	Moment
	[illegible]					
[illegible]	3200	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	2101	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Body *	8000				[illegible]	[illegible]
Payload *	[illegible]				[illegible]	[illegible]
					2	185,000

(I-lbs. about ⊈ of aft landing gear

* Estimated

Dead Load Stresses in Keel Beams

Section Modulus [Ref. C.]

Production Station	[illegible] Station	I [illegible]	C, distance to keel beams	Z_y Calculated
934	874	59300 in^4	98.2 in	610 in^3
960	900	116700	104.3	1130
[illegible]	918	30000	97.9	1330

Gross Weight = 135,000#

M = 985,000"# [Ref pg. 20]

For Z_y use 1130 in since smallest section modulus.

The bending stress $= \frac{985,000 \times 12}{1130} = -10,500$ psi

To be conservative, add this stress to all the strain gage readings obtained for the keel beams with sign of dead load stress to be of same sign as the stresses read from the oscillographs during arrestment, see pages 23 to 25.

Gross Weight = 220,000#

Add algebraically the strain gage readings from pages 18 and 19. To be conservative add this increase in stress for the gages under consideration to the 10,500 psi stress regardless of sign. This now

gives the dead load stresses for 220,000# gross weight. Next add these stresses to stresses obtained during arrestment as explained above for 135,000# gross weight, See pages 23 to 25.

PREPARED BY ______ CHECKED BY ______ DATE ______

ALL-AMERICAN ENGINEERING CO.

DU PONT AIRPORT - WILMINGTON, DELAWARE

MODEL NO. ______ REPORT NO. ______

Stresses @ Keel Beam

Project Run No.	Engaging Velocity	Distance from ℄	Gross Weight	S-28 ‡ Sta 852	Dead Load Stress	Total * Stress	S-32 ‡ Sta 978	Dead Load Stress	Total * Stress
	knots	ft.	lbs	psi	psi	psi	psi	psi	psi
1	80.8	on ℄	135000	N.R.	+10500	—	N.R.	-10500	—
2	120.5	"		6860		17360	-2430		-12930
3	106.5	"		5680		16130	-2420		-12920
4	119.2	"		6100		16600	-1160		-11660
5	128.2	"		8480		18980	-2320		-12820
6	135.6	"		3420		13920	-2190		-12690
7	78.4	40		2200		12700	0		-10500
8	100.1	"		N.R.		—	N.R.		—
9	116.2	"		7200		17700	-2850		-13350
10	130.2	"	135000	9510	+10500	20010	-2560	-10500	-13060
11	95.5	on ℄	220000	2570	+11370	13940	-3430	-11672	-15102
12	101.1	"		7010		18380	-3320		-14992
13	114.7	"		8900		20270	-8600		-20272
14	123.0	"		11650		23020	-2650		-14322
15	129.8	"		11650		23020	-1492		-13164
16	78.5	20		5350		16720	-3540		-15212
17	104.2	"		8500		19870	-3700		-15372
18	121.0	"		9600		20970	-4870		-16542
19	79.5	40		5550		16920	-3480		-15152
20	102.4	"		2840		14210	-2610		-14282
21	127.4	"		6630		18000	-6580		-18252
22	94.0	60		5900		17270	-4700		-16372
23	106.5	"		8970		20340	-6080		-17752
24	115.4	"		8830		20190	-5420		-17092
25	126.0	"		10450		21820	3380		-15052
26	116.0	40		9900		21270	-5420		-17092
27	123.2	20	220000	8250	+11370	19620	-5420		-17092
28	76.4	10	175000	2360	+12060	14420	-2540	-11672	-14212

* Conservative see pg 21 & 22

‡ Ref. Pg. 59

PREPARED BY________ **ALL-AMERICAN ENGINEERING CO.** PAGE 24

CHECKED BY________ DU PONT AIRPORT – WILMINGTON, DELAWARE MODEL NO.________

DATE________ REPORT NO.________

Stresses @ Keel Beam

Project Run. No.	Engaging Velocity	Distance From ℄	Gross Weight	S-30 ǂ Sta 945	Dead Load Stress	Total Stress *	S-33 ǂ Sta 945	Dead Load Stress	Total Stress *
	knots	ft.	lbs.	psi	psi	psi	psi	psi	psi
1	80.8	On ℄	135000	N.R	+10500	—	N.R	+10500	—
2	120.2			0		+10500	0		10500
3	106.5			—		—	2400		12900
4	119.2			0		10500	3140		13640
5	128.2			4570		15070	2590		13090
6	135.6			7750		18250	3370		13870
7	72.4	40		0		0	0		10500
8	102.1			N.R		—	N.R.		—
9	116.2			6550		17050	4450		14950
10	130.2		135000	12000	+10500	22500	4050	+10500	14550
11	35.5	On ℄	220000	0	+11565	11565	2400	+11627	14027
12	101.1	"		0		11565	2220		13847
13	114.7			3470		15035	3550		15177
14	123.0			6530		13095	4280		15907
15	129.6			4120		15685	3900		15527
16	78.5	20		975		12540	2880		14507
17	104.2			3410		14975	N.R.		—
18	121.0	"		3320		14885	3820		15447
19	79.5	40		985		12550	3050		14677
20	102.4			12500		24065	2270		13897
21	127.4			3940		15505	5300		16927
22	94.0	60		2630		14195	2280		13907
23	106.8	"		3650		15215	2850		14477
24	115.4			3980		15545	4020		15647
25	126.0			3320		14885	4020		15647
26	116.0	40		3900		15465	4020		15647
27	123.2	20	220000	3900		15465	2870	+11627	14497
28	96.4	10	175000	0	+11565	11565	1910	+12182	14092

* Conservative see pg. 21 & 22

ǂ Ref. Pg. 59

PREPARED BY__________ **ALL-AMERICAN ENGINEERING CO.** PAGE 25

CHECKED BY__________ DU PONT AIRPORT – WILMINGTON, DELAWARE MODEL NO.________

DATE__________ REPORT NO.________

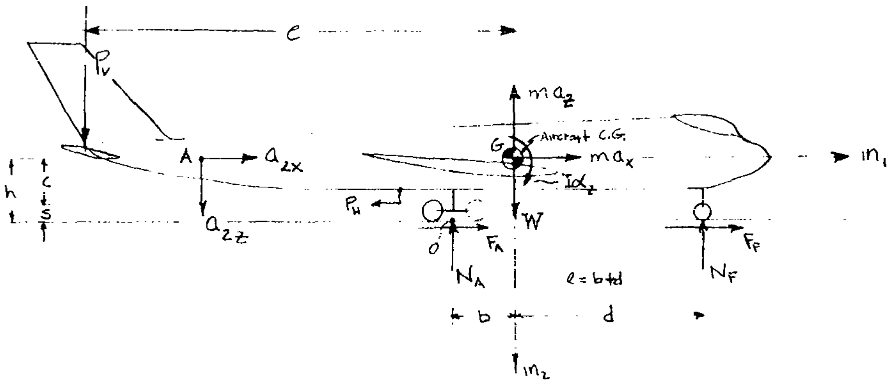
Stresses @ Keel Beam

Project Run No.	Engaging Velocity	Distance From ℄	Gross Weight	S-15 ‡ Sta. 865	Dead Load Stress	Total Stress *	S-29 ‡ Sta 870	Dead Load Stress	Total Stress *
	knots	ft.	lbs.	psi	psi	psi	psi	psi	psi
1	80.8	on ℄	135000	5600	+10500	16100	N.R.	+10500	—
2	120.8	"		—		—	4470		14970
3	106.5	"		5480		15980	4870		15370
4	119.2	"		6690		17190	5510		16010
5	128.2			7390		17890	7080		17580
6	135.6			9500		20000	6840		17340
7	78.4	40		3370		13870	1960		12460
8	100.1			17300		17800	N.R.		—
9	116.2	"		7000		17500	6500		17000
10	130.2		135000	8050	+10500	18550	7450	+10500	17950
11	85.5	on ℄	220000	17700	+21172	38872	2250	+11882	14132
12	101.1			1350		28522	6350		18232
13	114.7			8020		29192	8680		20562
14	123.0			11400		32572	9690		21572
15	129.8	"		10600		31772	10150		22032
16	78.5	20		6450		27622	0		11882
17	104.2	"		9200		30372	8950		20832
18	121.0	"		9500		30672	6660		18542
19	79.5	40		6330		27502	0		11882
20	102.4			8810		29982	2840		14722
21	127.4			12000		33172	10650		22532
22	94.0	60		6520		27692	8860		20742
23	106.8			9260		30432	6520		18402
24	115.4			9950		31122	8890		20772
25	126.0			10300		31472	11850		23732
26	116.0	40		9950		31122	8890		20772
27	123.2	20	220,000	6630		27802	7700	+11882	19582
28	96.4	0	175000	3315	+21172	24487	0	+12470	12470

* Conservative see pg. 21 & 22

‡ Ref. Pg. 59

NOSE GEAR LOAD



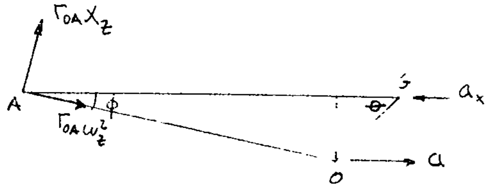
W = Gross Weight
m = Mass of Airplane
I = Mass Moment of Inertia about airplane C.G
α_z = Pitching Angular Acceleration
ω_z = Pitching Angular Velocity
n_1 & n_2 = Unit vectors fixed at airplane C.G.
a_x = Acceleration along n_1 direction
a_z = Acceleration along n_2 direction.
F_A & F_F = Frictional Forces of aft wheels & nose wheels respectively
N_A & N_F = Aft wheels normal load & nose gear load
P_H = Hook Load
P_V = Vertical load on horizontal tail. *

Assumptions

1. Assume rigid body

*: Ref. a.

$$\mathbf{a}^A = \mathbf{a}^{A/O} + \mathbf{a}^O$$



ϕ is small angle

$$a_{2x}\, m_1 + a_{2z}\, m_2 = (r_{OA}\,\omega_z^2 \cos\phi + r_{OA}\alpha_z \sin\phi)\, m_1 + (r_{OA}\,\omega_z^2 \sin\phi - r_{OA}\,\alpha_z \cos\phi)\, m_2 + a\, m_1$$

With $\cos\phi \cong 1$ & $\sin\phi \cong \phi$

$$(a_{2x} - r_{OA}\,\omega_z^2 - r_{OA}\alpha_z\,\phi - a)\, m_1 + (a_{2z} - r_{OA}\,\omega_z^2\,\phi + r_{OA}\,\alpha_z)\, m_2 = 0$$

then

$$r_{OA}\,\omega_z^2\phi + r_{OA}\,\alpha_z\,\phi^2 - a_{2x}\,\phi + a\,\phi = 0$$

$$-r_{OA}\,\omega_z^2\,\phi + r_{OA}\,\alpha_z + a_{2z} = 0$$

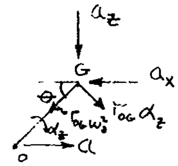
$$r_{OA}\,(\phi^2+1)\,\alpha_z + \phi\,(a - a_{2x}) + a_{2z} = 0$$

$$\alpha_z = -\frac{1}{r_{OA}}\left[\frac{\phi\,(a - a_{2x}) + a_{2z}}{(1+\phi^2)}\right]$$

$\phi^2 \cong 0$

$$\alpha_z = -\frac{1}{r_{OA}}\left[\phi\,(a - a_{2x}) + a_{2z}\right]$$

Lets find a



$$a^G = a^{G/O} + a^O$$

$w_z^2 \approx 0$ small

$$a_x = -r_{OG}\alpha_z \cos\theta - a$$

$$a = -(r_{OG}\alpha_z \cos\theta + a_x)$$

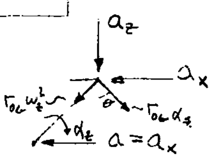
Place a into α_z in above eq

$$\alpha_z = -\frac{1}{r_{OA}}\left[\phi\left(-r_{OG}\alpha_z\cos\theta - a_x - a_{zx}\right) + a_{zz}\right]$$

$$\alpha_z\,(r_{OA} - r_{OG}\,\phi\cos\theta) = -\left[-\phi(a_x + a_{zx}) + a_{zz}\right]$$

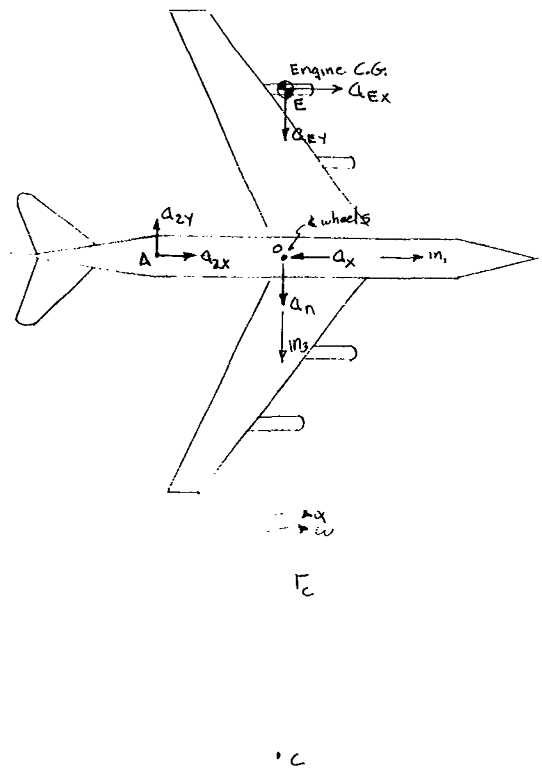
$r_{OG}\cdot\phi\cdot\cos\theta \approx 0$ small therefore $a = -a_x$

$$\boxed{\alpha_z = -\frac{1}{r_{OA}}\left[-\phi(a_x + a_{zx}) + a_{zz}\right]} \quad \text{------ (1)}$$



$w_z^2 \approx 0$ small

$$a_z = r_{OG}\cdot\alpha_z\cdot\cos\theta \quad \text{------- (1a)}$$



$$\mathbf{a}^E = \mathbf{a}^{E/O} + \mathbf{a}^O$$

$$a_{Ex}\, n_1 + a_{Ey}\, n_3 = r_{OE}\,\omega_y^2\, n_3 + r_{OE}\,\alpha_y\, n_1 - a_x\, n_1 + a_n\, n_3$$

$$(a_{Ex} - r_{OE}\,\alpha_y + a_x)\, n_1 + (a_{Ey} - r_{OE}\,\omega_y^2 - a_n)\, n_3 = 0 \quad \text{-----}$$

$$\mathbf{a}^A = \mathbf{a}^{A/O} + \mathbf{a}^O$$

$$a_{2x}\,\mathbf{n}_1 - a_{2y}\,\mathbf{n}_3 = r_{OA}\,\omega_y^2\,\mathbf{n}_1 - r_{OA}\,\alpha_y\,\mathbf{n}_3 + a_n\,\mathbf{n}_3 - a_x\,\mathbf{n}_1$$

$$(a_{2x} - r_{OA}\,\omega_y^2 + a_x)\,\mathbf{n}_1 + (-a_{2y} + r_{OA}\,\alpha_y - a_n)\,\mathbf{n}_3 = 0 \quad \text{---} \quad (3)$$

From eq (2) & (3)

$$\alpha_y = \frac{a_{Ex} + a_x}{r_{OE}}$$

$$a_n = r_{OA}\,\alpha_y - a_{2y}$$

Then
$$a_n = \frac{r_{OA}}{r_{OE}}(a_{Ex} + a_x) - a_{2y} \quad \text{---} \quad (4)$$

Also from eq (2) & (3)

$$\omega_y^2\, r_{OE} = a_{Ey} - a_n$$

$$\&\quad \omega_y^2\, r_{OA} = a_{2x} + a_x$$

Eliminate ω_y^2

$$\frac{r_{OE}}{r_{OA}}(a_{2x} + a_x) = a_{Ey} - a_n$$

$$a_{2x} = \frac{r_{OA}}{r_{OE}}(a_{Ey} - a_n) - a_x \quad \text{---} \quad (5)$$

$\sum F_{in_1} = 0$ [See fig. on pg. 27]

$$F_A + F_F = P_H - ma_x$$

$\sum F_{in_2} = 0$

$$N_F + N_A = W + P_V - ma_z$$

$\sum M_{CG} = 0$

$$I\alpha_z - N_F \cdot d + N_A b - (F_A + F_F) h + P_H \cdot c - P_V \cdot e = 0$$

Place N_A & $(F_A + F_F)$ into this eq.

$$I\alpha_z - N_F \cdot d + (W + P_V - ma_z - N_F) b - (P_H - ma_x) h + P_H c - P_V e = 0$$

$$N_F (b+d) = I\alpha_z + Wb + P_V b - ma_z b - P_H h + ma_x h + P_H c - P_V e$$

$\ell = b + d$

$$N_F = \frac{1}{\ell}\left[I\alpha_z + P_H (c-h) + ma_x h + Wb + P_V (b-e) - ma_z b \right]$$

with $(c-h) = -s$

$$\boxed{N_F = \frac{1}{\ell}\left[I\alpha_z - P_H S + ma_x h + Wb - P_V (e-b) - ma_z b \right]} \quad (6)$$

where $e > b$

$a_z = r_{cg} \alpha_z \cos\theta$ [see pg. 29]

PREPARED BY

CHECKED BY

DATE

ALL-AMERICAN ENGINEERING CO.

DU PONT AIRPORT - WILMINGTON, DELAWARE

PAGE 33

MODEL NO.

REPORT NO.

Mass Moments of Inertia about [illegible]

Component	Wt. *	Mass	Balance Arm of Components *	C.G. ‡ Balance Sta.	ℓ = (Bal. Arm − C.G.)	ℓ	ℓ^2	I ≅ $m\ell^2$	
	lbs.	Slugs	in	in	in	ft	ft^2		
Structure	60267	1870	903.1	835.6	67.5	5.62	31.60	59[illegible]	
Engines	18770	582	808.0	"	27.6	2.30	5.29	3070	
Equip. (Fixed)	20005	623	723.9		111.7	9.29	[illegible]	[illegible]	
Crew	850	264	193.4		642.2	53.6[illegible]	[illegible]	[illegible]	
Fuel Oil	1117	34.7	799.4		36.2	3.02	9.10	3.5	
Equip. Misc	[illegible]	33.5	[illegible]		36.9	3.07	9.40	3.5	
Payload W	117,911	3660	905.6		70.0	5.82	34.0	124,[illegible]	
							I =	316,300	Slugs-ft^2

* Obtained from aircraft log.

‡ Ref ℄

Example Calculation

Run 25 Engaging Velocity = 126.0 knots 60 ft of centerline

$a_{zz} = .40 \cdot 32.2 = -12.9$ ft/sec²
$a_{Ex} = 1.12 \cdot 32.2 = -36$ ft/sec²
$a_{Ey} = .44 \cdot 32.2 = 14.1$ ft/sec²
$a_x = .85 \cdot 32.2 = 27.4$ ft/sec²
$P_H = 183{,}800^{\#}$ $P_v = 7750^{\#}$
$W = 220{,}000^{\#}$
$m = \frac{220000}{32.2} = 6850$ slugs
$I = 316{,}800$ slugs-ft² [Ref. Pg. 33]
$s = 35$ ft
$h = 9.58$ ft
$e = 60.39$ ft
$\ell = 50.67$ ft
$b = 4.29$ ft
$r_{OA} = (35^2 + 9.58^2)^{1/2} = 36.5$ ft $r_{OG} = (9.58^2 + 4.29^2)^{1/2} = 10.5$ ft
$r_{OE} = 46.0$ ft
$\phi = \text{arc tan}\ \frac{9.58}{35} = \text{arc tan}\ .274$ $\theta = \text{arc cot}\ \frac{4.29}{9.58} = \text{arc cot}\ .447 = 66.8°$

a_{zy} was not measured for this run.

Use $a_{zy} = .37 \cdot 32.2 = -11.9$ ft/sec² which is a_{zy} measured for Run 21 (Vel = 127.4 knots, 40' off center line). Run 21 being similar to Run 25.

From eq ④
$$a_n = \frac{36.5}{46.0}(-36 + 28.2) + 11.9 = \underline{\underline{+5.7 \text{ ft/sec}^2}}$$

From eq ⑤
$$a_{zx} = \frac{36.5}{46.0}(14.1 - 5.7) - 28.2 = \underline{-21.5} \text{ ft/sec}^2$$

From eq ①

$$\alpha_z = \frac{-1}{36.5}\left[-.274(28.2-21.5) - 12.9\right]$$

$$\alpha_z = \frac{-1}{36.5}(-1.85 - 12.9) = +.403 \ \text{rad}/\text{sec}^2$$

$$a_z = r_{0G}\ \alpha_z \times \cos\theta \quad [\text{Ref. eq } (1a)]$$

$$a_z = 10.5 \cdot .403 \times \cos 66.8^\circ = 1.67\ \text{ft}/\text{sec}^2$$

From Eq. ⑥

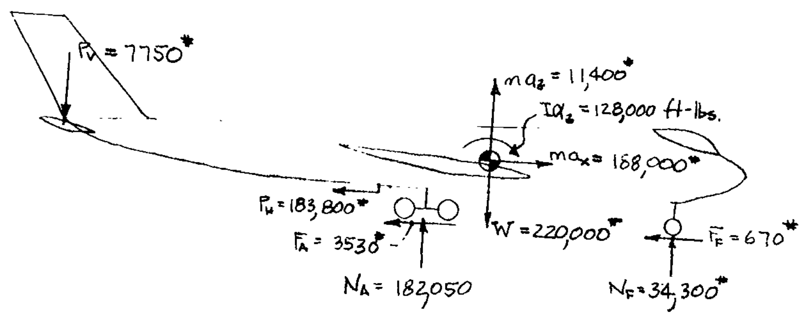
$$N_F = \frac{1}{50.67}\left[316{,}800(.403) - 183800 \cdot 35 + 6850 \times 27.4 \times 9.58 + 220000 \cdot 4.29 + 7750(60.39 - 4.47) - 6850 \cdot 1.67 \cdot 4.29\right]$$

$$N_F = \frac{1}{50.67} \cdot \left[128{,}000 - 641000 + 1800{,}000 + 940000 - 435000 - 49000\right]$$

$$N_F = \frac{1}{50.67} \times 1{,}743{,}000 = \underline{\underline{34{,}300^{\#}}}$$

See free body diagram of forces acting on airplane, page

Free body diagram of forces acting on airplane during arrestment for run 25.



$$\mu \text{ (coeff. of friction)} = \frac{ma_x - P_H}{(N_A + N_F)} = \frac{188000 - 183800}{216350} = .0195$$

$$F_A = .0195 \cdot 182050 = 3530^{\#} \quad \text{or } 882^{\#}/\text{Tire}$$

$$F_F = .0195 \cdot 34300 = 670^{\#}$$

The justification for using run 25 as an example calculation is as follows.

If neglecting the friction forces which are small magnitude wise in comparison to P_H & ma_x, we then obtain $P_H = ma_x$ from summing horizontal forces.
Revising eq. 3 we get

$$N_F = \frac{1}{\ell}\left[IX_z - P_H S + P_H h + Wb - P_V(e-b) - ma_z b \right]$$

$$N_F = \frac{1}{\ell}\left[IX_z + Wb + P_H c - P_V(e-b) - ma_z b \right]$$

where $e > b$

N_F depends largely on W, P_H, & P_V. At higher speeds P_H is maximum & at larger gross weights P_V is smallest in magnitude.
Therefore the nose gear load, N_F, is maximum at higher speeds & maximum gross weights.

It is to be noted that P_V (vertical load on horizontal tail) is known for the 220,000# gross weight [see ref. a] with a velocity of 130 knots and would be difficult

to obtain for other speeds and gross weights.

The vertical acceleration at pt. A (see p. 27) was measured only for some of the 220,000 lb. gross weight runs.

CROSS WIND STRESSES

Cross Wind Stress in Fuselage @ Balance Sta 887

$D = C_D A \frac{\rho V^2}{2}$

D = Drag force
C_D = Coefficient of drag
A = Projected area
ρ = Density or mass/volume
V = Wind Velocity

Assume $V = 20$ mi/hr and acting 90° to aircraft.

$V = \frac{20 \times 5280}{3600} = 29.4$ ft/sec

$\rho = \frac{\gamma}{g} = \frac{.0763}{32.2} = .00237$ slugs/ft³   where γ = specific weight

Vertical Tail

with $\frac{b}{h} = \frac{15}{24.5} < 1$ $C_D = 1.17$ [Ref. d]

$A = 15 \times 24.5 = 368$ ft²

$(\text{Drag})_{V.T.} = 1.17 \times 368 \times \frac{.00237 \times \overline{29.4}^2}{2} = 443^{\#}$

Fuselage

with $\frac{b}{h} = \frac{62.5}{14.25/2} = 8.9$ $C_D = .75$ [Ref. d]

$A = 62.5 \times 7.1 = 444$ ft²

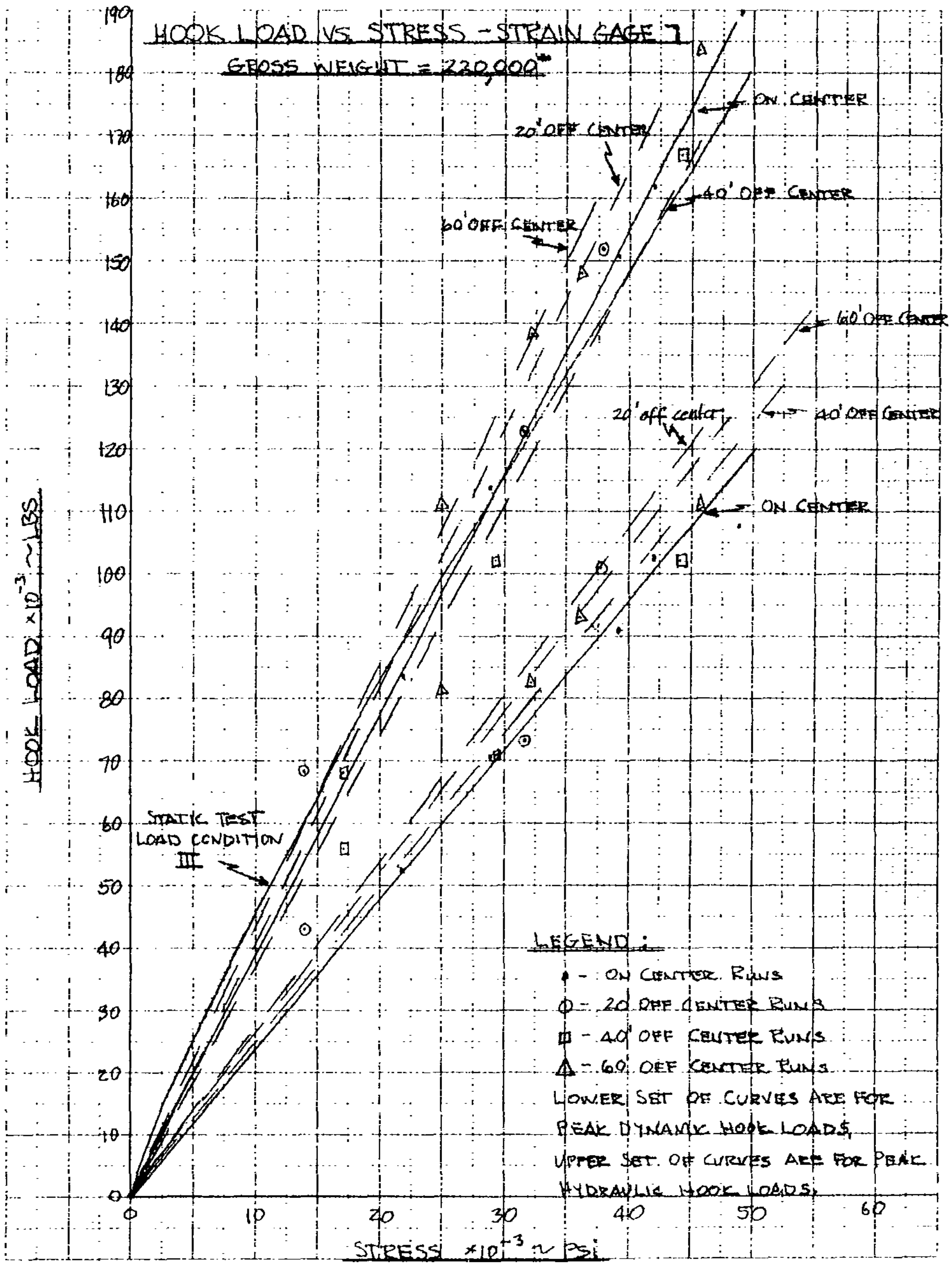
$(\text{Drag})_F = .75 \times 444 \times \frac{.00237 \times \overline{29.4}^2}{2} = 342^{\#}$

Moment at Bal. Sta 887

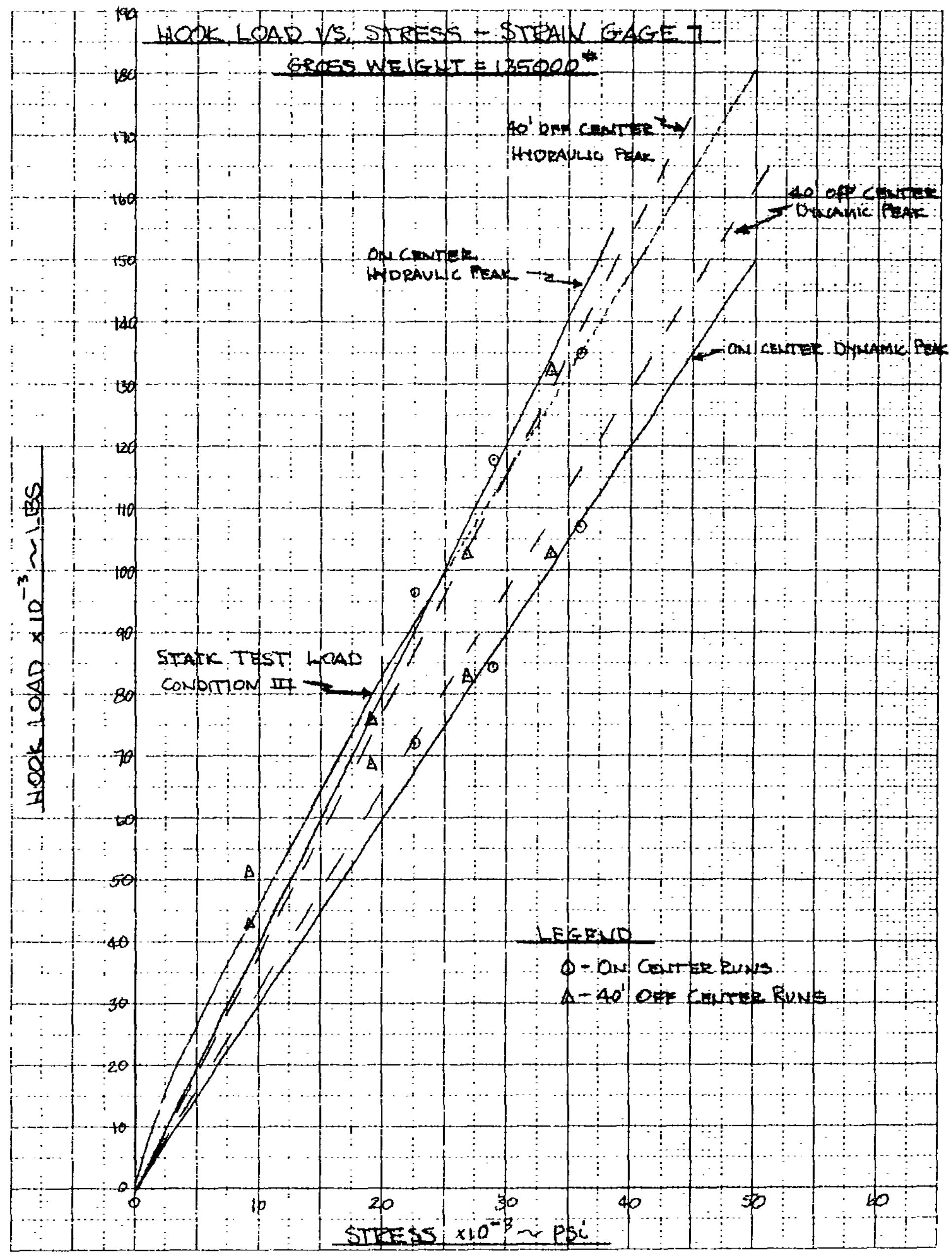
$$M = 443 \cdot 55 + 342 \cdot \frac{62.5}{3} = \underline{\underline{31,550 \text{ ft-lbs}}}$$

Z_Y (about lateral axis) = 1130 in^3 at Balance Sta 900 [Ref. Pg. 21]

If we assume $\frac{1}{10}$ of 1130 in^3 for Z_Z (about vertical axis) the stress value would be $\frac{31550}{113} = 279$ psi which is low.



HOOK LOAD VS. STRESS - STRAIN GAGE 7
GROSS WEIGHT = 220,000#
ON CENTER
20' OFF CENTER
40' OFF CENTER
60' OFF CENTER
60' OFF CENTER
20' off center
40' OFF CENTER
ON CENTER
STATIC TEST LOAD CONDITION III
LEGEND:
• - ON CENTER RUNS
⊙ - 20' OFF CENTER RUNS
⊡ - 40' OFF CENTER RUNS
△ - 60' OFF CENTER RUNS
LOWER SET OF CURVES ARE FOR PEAK DYNAMIC HOOK LOADS
UPPER SET OF CURVES ARE FOR PEAK HYDRAULIC HOOK LOADS.
HOOK LOAD ×10^-3 ~ LBS
STRESS ×10^-3 ~ PSI
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190


HOOK LOAD VS. STRESS - STRAIN GAGE 7
GROSS WEIGHT = 135000#
40' OFF CENTER HYDRAULIC PEAK
40' OFF CENTER DYNAMIC PEAK
ON CENTER HYDRAULIC PEAK
ON CENTER DYNAMIC PEAK
STATIC TEST LOAD CONDITION III
LEGEND
○ - ON CENTER RUNS
△ - 40' OFF CENTER RUNS
HOOK LOAD x10⁻³ ~ LBS
STRESS x10⁻³ ~ PSI
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190

REFERENCES

a. Phone call from M. C. Wardle (All American Engineering Co.) to Richard Sliff (FAA test pilot) at Boeing Aircraft Co., Seattle, Washington.

b. "Prototype Arresting Hook Installation Design for FAA-Boeing 720 Aircraft," All American Engineering Report M-635B

c. Telegram from Boeing Aircraft Co., Seattle, Washington to John Clarkson (All American Engineering Co.), Reference No. 6-7776-226.

d. Aero Dynamic Drag, Book by Sighard F. Hoerner

e. Verbal conversation between John Clarkson (All American Engineering Company) and Dean Crimm (FAA weights engineer).

APPENDIX

Appendix C

Boeing 720 and 707 hooks tested at Swarthmore College, Pennsylvania

The purpose of this part of the report is to interpret the findings of the Boeing 720 and 707 hooks tested at Swarthmore College, Pennsylvania on July 24, 1962.

Erroneous strain gage readings were obtained from the Boeing 707 hook because the strain gages slipped. Readings were obtained for the Boeing 720 hook and are presented on page 47.

Both hooks were pulled to destruction and recorded on page 56.

LOADS CRITERIA

ARRESTING HOOK ASSEMBLIES, BOEING 707 AND 720 AIRCRAFT
S.O. 1734, Task 440

1. GENERAL

1.1 Scope - This criteria defines the load and load parameters which will govern the design and analysis of the arresting hook assemblies to be used on the Boeing 707 and 720 aircraft.

1.2 Description of Assemblies - Each arresting hook assembly will be of the Sheaffer spring hook type consisting of a flat plate shank welded to a hook point. A replacable light metal shoe will be bolted to the hook point to complete the assembly.

One hook assembly shall be designed to meet the arresting load requirements of the Boeing 707 aircraft, and the other hook assembly shall be designed to meet the arresting load requirements of the Boeing 720 aircraft.

The Boeing 707 hook assembly shall be readily adaptable to installation on the Boeing 720 aircraft. However, a weak link shall be incorporated as part of the installation in order to preclude the possibility of inadvertently applying to the 720 aircraft an arresting load exceeding the structural capability of the reinforced hard point. This will be accomplished by removing material from the 707 hook shank and the process will thus be an irreversible one.

The Boeing 720 hook assembly shall not be capable of installation on the Boeing 707 aircraft.

1.3 Requirements - References 5.1, 5.2, and 5.3 define all specifications for the assemblies. Structural requirements resulting from these are stated in the following sections.

2. LOADS

2.1 Limit Loads - Limit loads are defined as the maximum arresting loads to which the assemblies will normally be subjected. The limit loads will be different for the two assemblies, as noted below

Boeing 707 A/C	Boeing 720 A/C
350,000#	225,000#

2.2 Yield Loads - Defined as the loads at which yielding of the assemblies can be expected to occur. Obtained by multiplying limit loads by a yield load factor (paragraph 3).

3. LOAD FACTOR AND LOAD CYCLES

The factor listed below will be used to obtain the yield load as noted in paragraph 2.2.

3.1 Yield Load Factor, YLF = 1.15.

3.2 Number of Load Cycles - Each hook assembly shall have the structural capability of being cycled from zero load to limit load and back to zero load for a total of one hundred (100) cycles.

4. MARGIN OF SAFETY

Margins of safety shall be computed for critically loaded sections as follows:

$$M.S._{yield} = \left[(F_{t_y} / (YLF)(\text{Limit Load Stress}) \right] - 1$$

5. REFERENCES

5.1 AAE Sales Order 1485, dated 18 June 1962.

5.2 Addendum A to Sales Order Nos. 1470 thru 1485 dated 18 June 1962.

5.3 Initial Plan - Mod. 3500 Follow-On Work, Inter-Office reference (Program Planning) EPP-1, J. N. Eustis, dated 19 June 1962.

6. APPROVAL

B. R. Sheaffer — J. Clarkson

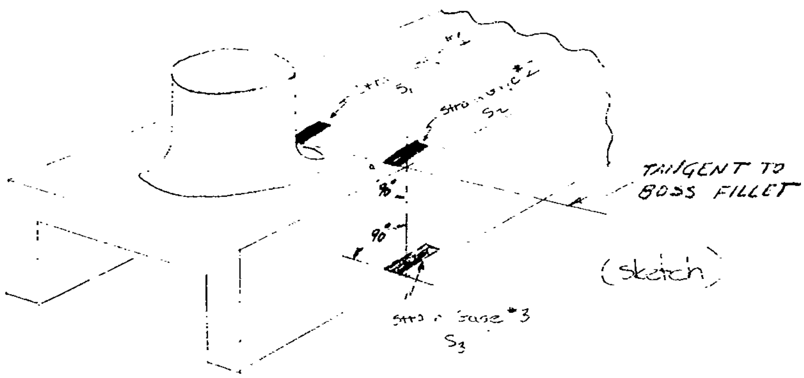
W. Schlegel — F. M. Highley, Jr.

M. C. Wardle — B. J. Salvadori

25 June 1962

Strain Gage Locations

Boeing 720 Hook



(Sketch)

Hook Shank

Instrumentation Data

LOAD	Pull #1 Strain ×10⁶	Change in Strain ×10⁶	Pull #2 Strain ×10⁶	Change in Strain ×10⁶	Pull #3 Strain ×10⁶	Change in Strain ×10⁶		Avg. Strain *
Kips	in/in	in/in	in/in	in/in	in/in	in/in		in/in
0								
25	830		830		[illegible]		Strain	[illegible]
50	1640	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Gage	[illegible]
75	2490	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
100	3330	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	#1	[illegible]
125	4175	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
150	4370	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
175	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Tension	[illegible]
200	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]
225	[illegible]	[illegible]	[illegible]	[illegible]	679			[illegible]
0	0							
25	410		560		570			[illegible]
50	910	500	1100	540	1110	520		[illegible]
75	1520	540	1640	540	1650	540	Strain	[illegible]
100	2070	540	2160	520	2180	530		2120
125	2600	530	2700	540	2710	530	Gage	[illegible]
150	3135	535	3230	530	3220	510		[illegible]
175	3630	545	3740	510	3730	510	#2	[illegible]
200	4220	540	4265	525	[illegible]	[illegible]		4250
225	4760	540	4770	505	4780	515	Tension	[illegible]
0								
25	[illegible]		480		[illegible]			
50	[illegible]	440	900	420	[illegible]	[illegible]		[illegible]
75	[illegible]	420	1310	410	1300	[illegible]	Strain	[illegible]
100	[illegible]	[illegible]	1700	[illegible]	[illegible]	[illegible]		[illegible]
125	[illegible]	400	2090	390	[illegible]	[illegible]	Gage	[illegible]
150	[illegible]	410	2490	400	2470	[illegible]		[illegible]
175	[illegible]	400	[illegible]	310	[illegible]	[illegible]	#3	[illegible]
200	[illegible]	390	3240	350	3240	[illegible]	Compression	[illegible]
225	[illegible]	380	3600	360	[illegible]	[illegible]		[illegible]

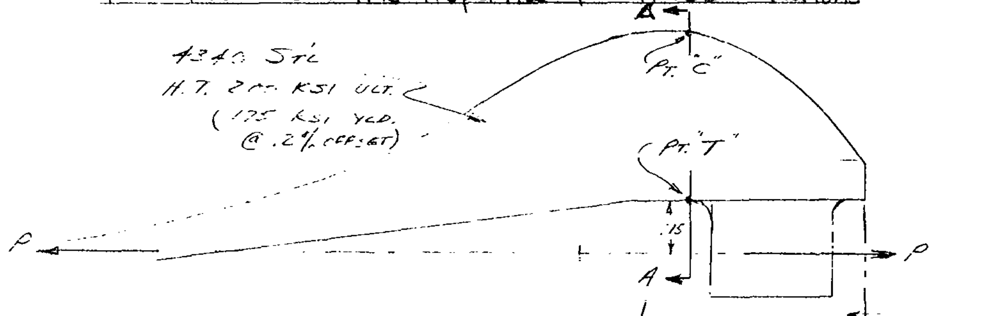
* For strain gage #1, Pull #1 not [illegible]

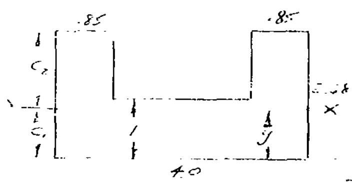
(1734-440)

BOEING 720 TAIL HOOK

(DWG 7253)

Theoretical Geometric Properties & Stress Relations





SECTION A-A

A	y	Ay	Ay²	I_c
2.30	.5	1.15	.575	.192
4.55	1.34	6.10	8.160	.73
6.85		7.25	8.735	2.922

$$\bar{y} = \frac{7.25}{6.85} = 1.06 = C_1 \qquad C_2 = 2.68 - 1.06 = 1.62''$$

$$I_x = 2.922 + 8.735 - (6.85)(1.06)^2 = 3.997 \text{ IN}^4$$

$$C = .75 + 1.06 = 1.81''$$

(a) STRESS AT SECT. A-A, ACCORDING TO STRAIGHT BEAM THEORY --

$$f_t = \frac{P}{A} + \frac{Pe\,C_1}{I} = \frac{P}{6.85} + \frac{P \times 1.81 \times 1.06}{3.997} = P(.146 + .48) = .6[illegible]\,P$$

$$f_c = \frac{P}{A} - \frac{Pe\,C_2}{I} = \frac{P}{6.85} - \frac{P \times 1.81 \times 1.62}{3.997} = P(.146 - .733) = -.587\,P$$

(b) STRESS ACCORDING TO INSTRUMENTATION —

$$E = \frac{\text{STRESS}}{\text{STRAIN}} = 29 \times 10^6 \text{ PSI (FOR 4340 STL.)}$$

$$f_t = f_c = 29 \times 10^6 \times (\text{STRAIN})$$

STRESSES AT SECTION A-A
(REF PG 50 (a) & (b))

APPLIED LOAD P KIPS ①	INSTRUMENT CALC. — GAGE #1 STRAIN μ IN/IN ②	GAGE #1 f_t KSI ③	GAGE #2 STRAIN μ IN/IN ④	GAGE #2 f_t KSI ⑤	GAGE #3 STRAIN μ IN/IN ⑥	GAGE #3 f_c KSI ⑦	STR. BEAM THEORY CALC. f_t KSI ⑧	STR. BEAM THEORY CALC. f_c KSI ⑨
0	0	0	0	0	0	0	0	0
25	270	7.8	540	15.7	457	-13.5	15.7	-14.7
50	1108	32.1	1067	31.0	885	-25.7	31.3	-29.4
75	1950	56.5	1607	46.6	1297	-37.6	47.0	-44.0
100	2775	80.4	2137	61.9	1690	-49.0	62.6	-58.7
125	3600	104.2	2670	77.5	2083	-60.5	78.3	-73.5
150	4325	126.2	3195	92.7	2473	-71.7	94.0	-88.0
175	5220	151.5	3717	107.7	2863	-83.1	109.8	-103.0
200	6028	175.0	4250	123.2	3243	-93.4	125.0	-117.5
225	6795	197.0	4770	138.5	3612	-103.9	141.0	-132.0

NOTES:

②, ④, & ⑥ – AVERAGE TOTAL STRAINS FROM TEST DATA SHEET page 49.

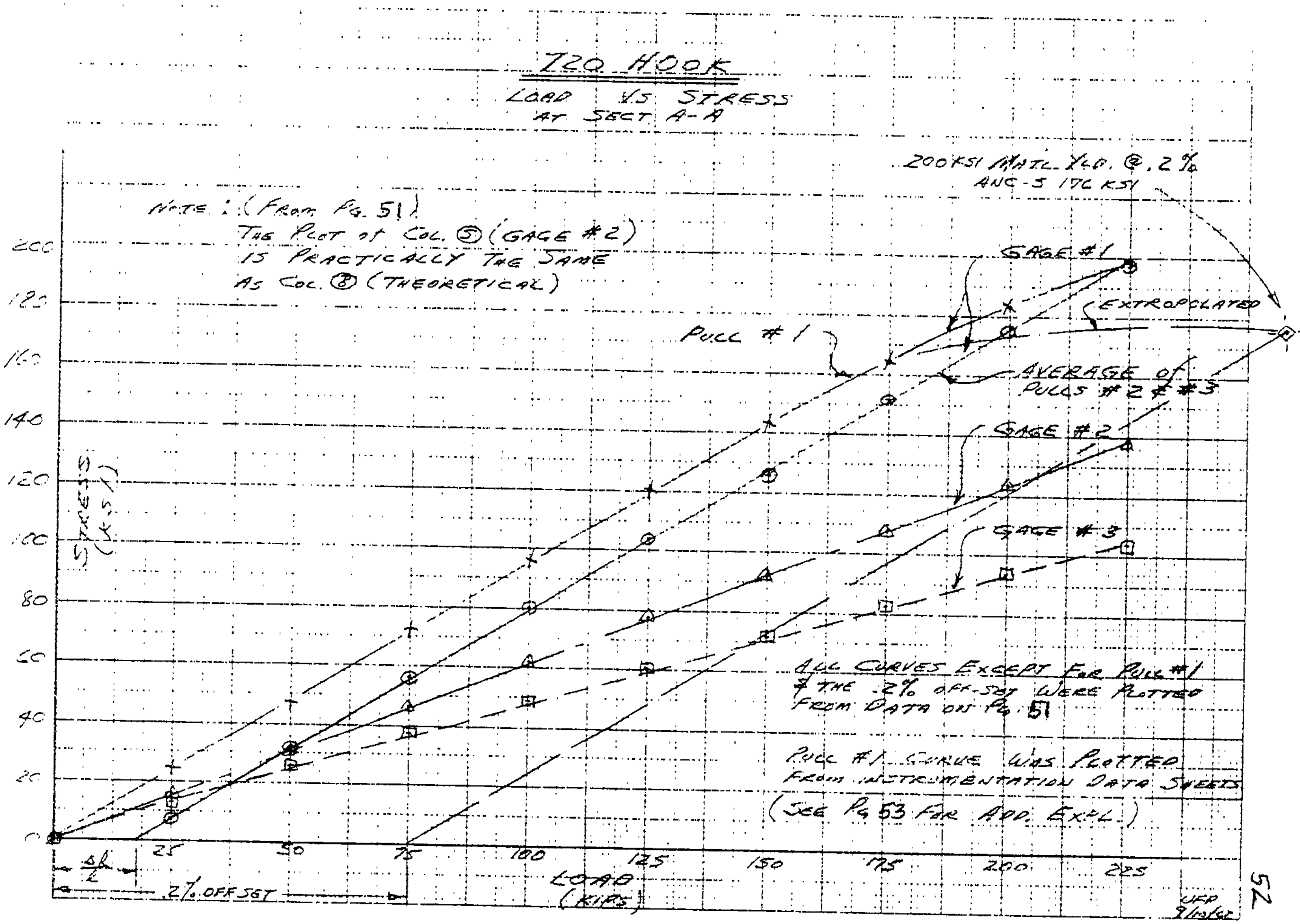
③ ⑤ & ⑦ – CALCULATED STRESS ACCORDING TO ②, ④ & ⑥ AND $E = 29 \times 10^6$ PSI (SEE PG. 50, ITEM (b)).

⑧ & ⑨ – CALCULATED STRESS ACCORDING TO STRAIGHT BEAM THEORY BASED ON THEORETICAL GEOMETRIC PROPERTIES OF SECTION (SEE PG. 50, ITEM (a)). ⑧ IS COMPARABLE TO ⑤, & ⑨ IS COMPARABLE TO ⑦.

$K_1 = \frac{⑤}{⑧}$ VARIES FROM 1 AT 25 KIP LOADING TO .981 AT 225 KIPS. THIS APPROXIMATES THE "STRAIGHT" BEAM THEORY.

$K_2 = \frac{⑦}{⑨}$ VARIES FROM [illegible] AT 25 KIPS TO .787 AT 225 KIPS. THIS MORE CLOSELY APPROX. THE "CURVED" BEAM THEORY.

NOTICE THAT PT. "T" IS ON THE "STRAIGHT" PORTION OF THE BEAM & PT. "C" IS ON THE "CURVED" PORTION.


720 HOOK
LOAD VS STRESS
AT SECT. A-A
NOTE: (FROM PG. 51)
THE PLOT OF COL. 5 (GAGE #2)
IS PRACTICALLY THE SAME
AS COL. 8 (THEORETICAL)
200 KSI MATL. YLD. @ .2%
ANC-5 176 KSI
GAGE #1
EXTRAPOLATED
PULL #1
AVERAGE OF PULLS #2 & #3
GAGE #2
GAGE #3
ALL CURVES EXCEPT FOR PULL #1
& THE .2% OFF-SET WERE PLOTTED
FROM DATA ON PG. 51
PULL #1 CURVE WAS PLOTTED
FROM INSTRUMENTATION DATA SHEETS
(SEE PG 53 FOR ADD. EXPL.)
STRESS (KSI)
0
20
40
60
80
100
120
140
160
180
200
25
50
75
100
125
150
175
200
225
LOAD (KIPS)
.2% OFFSET
UFP
9/10/62

UFP
9/11/62

INTERPRETATION OF CURVES ON PG 52

(1) ALL TEST PULLS (EXCEPT PULL #1 ON GAGE #1) WERE MADE WITHIN THE PROPORTIONAL LIMIT OF THE MATERIAL.

(2) PULL #1 ON GAGE #1 INDICATES THAT THE PROPORTIONAL LIMIT WAS EXCEEDED. SUCCEEDING PULLS ON THE SAME GAGE, HOWEVER SHOW A LINEAR RELATIONSHIP INDICATING THAT THESE SUCCEEDING PULLS WERE MADE WITHIN THE PROPORTIONAL LIMIT OF THE MATERIAL, WHICH WAS PROBABLY WORK-HARDENED BY THE FIRST PULL.

(3) THE CURVE OF PULL #1 ON GAGE #1 ABOVE THE PLOTTED POINT AT 165 KSI IS FICTICOUS SINCE THE PROPORTIONAL LIMIT HAS BEEN EXCEEDED.

(4) THE OFFSET $\frac{\Delta \ell}{\ell} = .057\%$ CALCULATED AS FOLLOWS:
(a) FROM CURVE ON PG 52, $\frac{\Delta \ell}{\ell} = 17.5$ KIPS
(b) FROM DATA SHEET page 49 FOR GAGE #1, PULLS #2 / #3; THE AVERAGE STRAIN INCREMENT FOR EACH 25 KIPS LOADING INCREMENT IS 816 µ IN./IN.
THEREFORE $\frac{816}{25} = \frac{X}{17.5}$; $X = 570$ µ IN./IN
570 µ IN./IN. = .00057 IN./IN. = .057 % IN./IN.

(5) THE EXTRAPOLATED PORTION OF THE CURVE FOR PULL #1 WAS ARRIVED AT AS FOLLOWS:
a) BY KNOWING THE MATL. YLD. = 176 KSI @ .2% OFFSET FOR 200 KSI ULT H.T. ALLOY STL. (REF ANC-5), DETERMINE THE EQUIVALENT LOAD FOR OUR PARTICULAR GAGE #1 READINGS. FROM DATA SHEET, page 49, IT IS FOUND THAT AN APPROX. 75 KIPS LOAD PRODUCES A 2000 µIN./IN. STRAIN (= .2%).
(b) DRAW A LINE THRU THIS POINT (AT 75 KIPS) PARALLEL TO THE STRAIGHT PORTION OF THE CURVE FOR PULL #1. WHERE THIS LINE INTERSECTS 176 KSI, DETERMINES THE .2% OFFSET YLD. POINT ON THE CURVE.
(c) REFERRING TO A TYPICAL "STRESS VS STRAIN" CURVE, FARE BETWEEN THE UPPER EXTREMITY OF THE

SFP
6/1/62

STRAIGHT PORTION OF THE CURVE FOR PULL #1 [illegible] IS YLD. PT. LOCATED IN STEP 6). KEEP IN MIND THAT THE YLD. PT. IS THE HIGHEST POINT OF THE EXTRAPOLATED CURVE.

* STRAIGHT BEAM THEORY VS CURVED BEAM THEORY

[illegible] [illegible] THE DATA ON PG 51 THE [illegible] [illegible] THE [illegible] IN THE CURVED BEAM THEORY [illegible] [illegible] THAT IS TO SAY THAT [illegible] [illegible] BE [illegible] FAIRLY ACCURATELY BY THE STRAIGHT BEAM FORMULA.

$$\sigma = \frac{P}{A} \pm \frac{Mc}{I}$$

[illegible] [illegible] FACTOR [illegible] BE APPLIED TO THE BENDING STRESS $\left(\frac{KMC}{I}\right)$ AS FOR A TYPICAL CURVED BEAM.

* STRESS CONCENTRATION.

AT THE INTERSECTION OF THE [illegible] POINT [illegible] [illegible] THE [illegible] PROFILE (LOCATION OF GAGE #1) A STRESS CONCENTRATION [illegible] [illegible] AS [illegible] BY THE SLOPE DIFFERENTIAL BETWEEN THE CURVES FOR GAGE #1 & GAGE #2. THE SLOPE OF THE STRAIGHT PORTION OF THE CURVE FOR PULL #1 ON GAGE #1 IS

$$\theta_1 = \tan^{-1} \frac{.299}{[illegible]} = \tan^{-1} .[illegible]$$ (SAME AS STR. BEAM THEORY)

\& THE SLOPE OF [illegible], FOR GAGE #2 [illegible]

$$\theta_2 = \tan^{-1} \frac{.296}{[illegible]} = \tan^{-1} .[illegible]$$

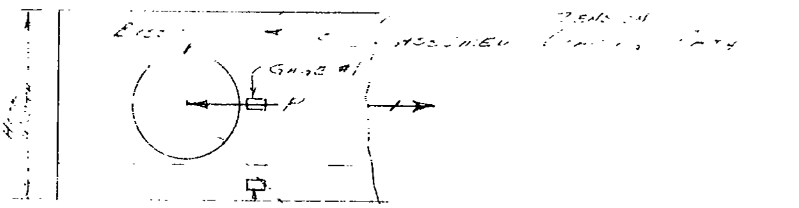
[illegible] THE STRESS CONCENTRATION FACTOR K_S [illegible] [illegible] THE RATIO OF THE SLOPES OR

$$K_S = \frac{.596}{.[illegible]87} = 1.5[illegible]$$

* SEE [illegible] [illegible] [illegible] EFFECT ON PG 5[illegible]

* Method of Loading Effect

Due To A "Fanning out" Effect of Load Which is Applied To The Boss, Perhaps All The Load Does Not Go Thru The Location At Gage # 2. If This is True, It May only Be Coincidental That The Gage Reading (Col 5 of Pg 51) Agrees With The Theoretical Calculation (Col. 8 of Pg 51), Coincidental To The Degree That Perhaps A Total Stress Increase Due To A Curved Beam Factor May Be Nullified By A Stress Decrease At This Point Because Only A Reduced Amount of The Total Load Passes Thru This Point Resulting in The Indicated Overall Factor (K) Approximately Equal To Unity Between 5 & 8 of Pg. [illegible]



Gage #2

Although What Has Been Said Above is True In General, It is Felt That This "Fanning Effect" is Negligible in The Specific Case of The 720 & 707 Hook Designs, Because:

(1) The Boss Diameter is Large in Comparison With The Hook Width.

(2) The Deepness of The Hook Design Beneath The Boss Affords Additional Load Paths To Distribute The Applied Load P More Uniformly To Gage #2.

This Comment on "Method of Loading Effect" is mentioned So The Results Derived From This Test Are Not indiscriminately Used For other Designs.

* See Pg. 54

[illegible]
9/12/[illegible]

(TEST HOOKS)

THEORETICAL CALCULATIONS OF BOEING 720 & BOEING 707 HOOKS

(SEE PG 50 FOR SECT. [illegible])

720 HOOK (7253) 4340 STL F_{tu} = [illegible] KSI F_{ty} [illegible] KSI @ .2%

P = 225 [illegible] # ([illegible])

f_t = $K_S \left(\frac{P}{A} + \frac{PEC_1}{I} \right)$ = 1.55 ([illegible] / [illegible] + [illegible] × 1.81 × [illegible] / 5.997)

= [illegible] ([illegible] + [illegible]) = [illegible]

SAME GEOMETRY

NOTE: ACTUAL TEST SPECIMEN [illegible]

F_{ey} = 185 KSI @ .02% & = [illegible] KSI @ .2%

[illegible] (REF [illegible] TESTING DATA)

707 HOOK [illegible] MARAGING ST STL. TEST SPECIMEN AT F_{tu} = 275 KSI

F_{ey} = 227 @ .02% & = 26[illegible] @ .2% [illegible]

P = 350 [illegible] # ([illegible]) [illegible]

f_t [illegible] × [illegible] = 351 [illegible]

NOTE: TEST RESULTS [illegible]

(a) 720 — [illegible] TO DESTRUCTION AT 353 K[illegible] AFTER 15[illegible] CYCLES @ 225 K[illegible]

ULT. FACTOR = $\frac{353}{225}$ 1.57

(b) 707 — PULLED TO DESTRUCTION AT 4[illegible] [illegible] AFTER 1[illegible] CYCLES @ 350 KIPS

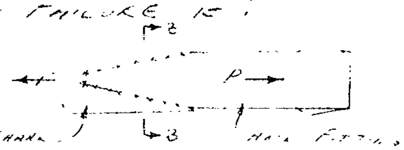
ULT. FACTOR = $\frac{4[illegible]}{350}$ = [illegible]

[illegible]

[illegible] TO TESTS [illegible]TED ON
[illegible] 725 & 707 [illegible]

[illegible] YIELD [illegible] EXCEEDED ON THE [illegible] [illegible] LIMIT LOAD [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] CONDITION [illegible] [illegible] OF [illegible] [illegible]CENTRATION. SINCE THE MATERIAL [illegible] DUCTILE [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]HARDEN-ING [illegible] [illegible] THAT THE [illegible] [illegible] [illegible] [illegible] [illegible].

[illegible] [illegible] FAILURE DID NOT OCCUR AT SECT. A-A (SEE P 50) [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] THE [illegible] [illegible] THE 725 & 707 [illegible] STRESS AT FAILURE IS:



[illegible] A [illegible] 1.75 IN^2

725 —
$f_c = \frac{358}{1.75} = 205$ KSI
[illegible] MATL. [illegible] [illegible]

707 —
$f_c = \frac{4??}{1.75} = 277$ KSI
[illegible] MATL. [illegible] [illegible]

THE TEST [illegible] [illegible]FULLY [illegible] [illegible] [illegible]; HOWEVER THEORETICAL [illegible] [illegible] MATERIAL [illegible].

[illegible] [illegible] BECAUSE THE BENDING [illegible] [illegible] IS NOT SYMMETRICAL [illegible] THE BENDING AXIS & THEREFORE THEORETICALLY SHOULD NOT BE CONSIDERED.

UFP
7/18/62

DEVELOPMENTAL CALCULATIONS LEADING TO THE DESIGN OF THE TEST HOOKS WERE DONE IN ROUGH FORM & ARE NOT IN A METHODICAL ORDER OWING TO NUMEROUS DESIGN & MATERIAL CHANGES. ALTHOUGH THESE CALCULATIONS ARE NOT IN REPORT FORM, THEY ARE ON FILE IN THE A.A.E. STRESS DEPT. THESE CALCULATIONS WERE PROVED TO BE TRUE BY THE SUCCEEDING TESTS.

THE FINAL DESIGN ANALYSIS IS IN GOOD FORM IN A.A.E. STRESS FILES. KNOWLEDGE GAINED FROM THE TEST RESULTS WAS USED IN ANALYZING THE FINAL DESIGN.

PERTINENT DRAWING LIST

	ASSEM. DWG.	SHANK DWG.	HOOK FITTING DWG.
FOR TEST:			
720 HOOK →	7251-1	7252	7253
707 HOOK →	7275-1	7277	7276
FINAL DESIGN:			
720 HOOK →	7251-2	725[illegible]	7260
707 HOOK →	7275-2	7277	7262

NOTE:

(a) DIFFERENCES BETWEEN 720 & 707 DESIGN:

1. MATERIAL –

@ 2% [illegible]

720 – 4340 STL F_{tu} = 260 KSI & F_{ty} = [illegible] KSI

707 – MARAGING S.S. F_{tu} = 295 KSI & F_{ty} = 240 KSI

2. SHANK WIDTH AT A/C ATTACHMENT –

720 – 11" WIDE

707 – 10" WIDE

(b) DIFFERENCE BETWEEN TEST HOOK & FINAL DESIGN:

1. HOOK FITTING THREAD LENGTH –

FINAL DESIGN IS 1/4" LONGER THAN TEST HOOK (INSIGNIFICANT STRESS WISE)

Appendix D

Strain gage data reduced during the NAFEC ~~rest~~ test. Total stress in the aircraft members monitored does not include deadload stress but rather arrested landing stress

PREPARED BY

CHECKED BY

DATE 10-19-62

ALL-AMERICAN ENGINEERING CO.

DU PONT AIRPORT - WILMINGTON, DELAWARE

MODEL NO.

REPORT NO.

Run #1 (80.8 knots)

Gage No.	$K \times 10^6$ in/in	D_R * $= R_c$	$F_z \times 10^6$ $= K/D_R$	ΔD $= D_2 - D_1$	$\epsilon \times 10^6$ $= F_z \times \Delta D$	$E \times 10^{-6}$	S psi $= E \cdot \epsilon$		
S7	2910	1.55	1880	.23	433	29.0	12600		
S8	2869	.18		0		10.5	0		
S9	"	.08		0		10.5	0		
S10	"	1.52	1885	-.20	377	10.3	-3900		
S11	"	1.65	1740	.30	522	"	5400		
S12	"	1.82	1578	.20	316	"	3260		
S13	2896	—		.35		"	—		
S14	"	1.70	1700	.20	340	"	2460		
S15	2869	.53	5420	.10	542	"	5600		
S16	2057	—				28.5	—		
S17	2057	.10	20570	-17	3500	28.5	-100000		
S18	1029	N.R.	—	—	—	28.5	—		
S19	2869								
S21	2896								
S22	2869								
S23	"								
S26	"								
S27	"			NO	RECORD				
S28	"								
S29	"								
S30	2896								
S31	"								
S32	"								
S33	2869								

* Estimated from Run #2 - R_c's for Run #1 Missing

PREPARED BY______ **ALL-AMERICAN ENGINEERING CO.** PAGE 61

CHECKED BY______ DU PONT AIRPORT - WILMINGTON, DELAWARE MODEL NO.______

DATE 10-19-62 Run #2 (120.8 KTS) 135 000# G.W. REPORT NO.______

Gage No.	$K \times 10^{+6}$ in/in	$D_R = R_c$	$F_2 = K/D_R \cdot 10^6$	$\Delta D = D_2 - D_1$	$\epsilon = F_2 \cdot (\Delta D) \cdot 10^6$	$E \times 10^{-6}$	S Psi $= E \times \epsilon$		
S7	2910	1.55	1875	.55	1030	29	29900		
S8	2869	.18	15950	.10	1595	10.5	16750		
S9	"	.08	35900	0	0	10.5	0		
S10	"	1.52	1885	.65	1225	10.3	12600		
S11	"	1.65	1740	.5	870	"	8550		
S12	"	—	—	.42	—	"	—		
S13	2896	—	—	.67	—	"	—		
S14	"	1.7	1700	.3	510	"	5250		
S15	2869	.53	5420	small	—	"	—		
S16	2057	—	—	small	—	28.5	—		
S17	2057	.10	20600	-.18	3710		-106,000		
S18	1029	.45	2290	-.93	2130	"	-61,000		
S19	2869	1.4	2040	.15	-307	10.3	3160		
S21	2896	1.3	2200	-.07	154	10.7	-1650		
S22	2869	.33	8680	0	0	10.3	0		
S23	"	.88	3240	.08	259	"	2660		
S26	"	1.52	1890	.30	568	"	5830		
S27		1.49	1920	±.28	538	"	±5520		
S28	"	1.29	2220	.30	665	"	6860		
S29	"	1.45	1970	.22	433	"	4470		
S30	2896	.26	11100	0	0	"	0		
S31	"	.36	8050	.12	965	"	-10000		
S32	"	.37	7850	±.03	235	"	-2430		
S33	2869	.37	7720	0	0	"	0		

PREPARED BY JC **ALL-AMERICAN ENGINEERING CO.** PAGE 67

CHECKED BY DU PONT AIRPORT – WILMINGTON, DELAWARE MODEL NO.

DATE OCT 20 1962 RUN #3 (106.5 Kts) REPORT NO.

	GAGE NO	K in/in	$R_c = DR$	$F_2 = K/DR$	ΔD DYN	ΔD HYD	$\epsilon = F_2(\Delta D) \times 10^{-6}$	E psi $\times 10^6$	$S = \epsilon E$ psi
1	S7	2910	1.57	1850	.31	.42	777	29.0	22500
2	S8	2869	.15	19120	0	.03	573	10.5	6020
3	S9	2869	.08	35900	0	0	0	10.5	0
4	S10	2869	+1.62	1770	.35	.47	832	10.3	+ 8560
5	S11	2869	1.64	1750	.35	.4	700	10.3	7210
6	S12	2869	1.82	1578	.3	.38	600	10.3	6180
7	S13	2896	—	—	.5	.58	—	10.3	—
8	S14	2896	1.75	1650	.22	.25	412	10.3	4240
9	S15	2869	.54	5320	.10	.10	532	10.3	5480
10	S16	2057	—	—	—	0	0	28.5	0
11	S17	2057	1.41	1460	-2.60		3790	28.5	108,000*
12	S18	1029	N.R.		—		—	28.5	—
					ΔD				
	S19	2869	1.4	2040	.06			[illegible]	[illegible]
	S21	2896	1.3	2200	.07			[illegible]	[illegible]
	S22	2869	.33	8680				10.3	
	S23	"	.88	3240	.07				[illegible]
	S26		.52	1870	.18				3520
	S27	"	1.49	1920	.25				4140
	S28	"	1.29	2220	.25				5680 +
	S29	"	1.45	1970	.24				4870 -
	S30	2896	.26	11100					— +
	S31	"	.36	3050	- .08				-6[illegible]
	S32	"	.37	7850	± .03				±2420 -
	S33	2869	.37	7720	.03				2400 +

* The max. Stress was estimated because at this station the trace ran off oscillograph paper.

PREPARED BY JC

ALL-AMERICAN ENGINEERING CO.

DU PONT AIRPORT -- WILMINGTON, DELAWARE

PAGE 63

CHECKED BY

MODEL NO.

DATE Oct. 20 1962

REPORT NO.

Run #4 (119.2 knots)

	GAGE NO	K	Rc	Fz K/DR	ΔD DYN	ΔD HYD	$\epsilon \times 10^{-6}$ Fz(ΔD)	$E \times 10^{-6}$ psi	S ϵE	
1	S7	2910	1.57	1850		.52	962	29.0	28900	
2	S8	2869	.15	19120		—	—	10.5	—	
3	S9		.08	35900	SMALLER THAN	—	—	10.5	—	
4	S10	"	1.63	1770	—	.48	850	10.3	8750	
5	S11	"	1.64	1750		.51	882	10.3	9080	
6	S12	"	1.82	1578		.30	472	10.3	4860	
7	S13	2896	—			.70	—	10.3	—	
8	S14	2896	1.73	1670		.30	501	10.3	5160	
9	S15	2869	.53	5420		.12	650	10.3	6690	
10	S16	2057	—	—		—		28.5	—	
11	S17	2057	1.42	1455		-3.0	-4365	28.5	-124000	*
12	S18	1029	N.R.	—	—	—	—	28.5	—	
					ΔD					
	S19	2869	1.4	2040	-.05			10.3	-1170	
	S21	2846	1.3	2200	.07			10.7	1650	
	S22	2869	.33	8680	0			10.3	0	
	S23	"	.81	3530	0			"	0	
	S26	"	1.55	1850	.19			"	3640	
	S27	"	1.49	1920	.34				6720	
	S28	"	1.32	2170	.27			"	6100	
	S29	"	1.50	1910	.28			"	5510	
	S30	2896	.26	11100	0			"	0	
	S31	"	.36	8050	.05			"	4170	
	S32	"	1.80	610	-.07			"	-1160	
	S33	2869	1.60	790	.17			"	3140	

* The max. stress was estimated because at this instant the trace ran off oscillagraph paper.

PREPARED BY J CLARKSON **ALL-AMERICAN ENGINEERING CO.** PAGE 64

CHECKED BY ______ DU PONT AIRPORT – WILMINGTON, DELAWARE MODEL NO. ______

DATE Oct. 20 1962 RUN # 5 (128.2 KNOTS) REPORT NO. ______

	GAGE NO	K	RC	F_2 K/DR	ΔD	$\epsilon \cdot 10^{-6}$ $F_2(\Delta D)$	$E \cdot 10^{-6}$ PSI	S ϵE		
1	S7	2910	1.58	1850	.58	1072	29	31100		
2	S8	2869	.12	23900	.02	478	10.5	5030		
3	S9	2869	.08	17500	-.02	-350	10.5	-3680		
4	S10	2869	1.64	1770	-.75	-1330	10.3	-13700		
5	S11	2869	1.65	1850	.60	1110	10.3	11420		
6	S12	2869	1.80	1595	.48	766	10.3	7900		
7	S13	2896	NO RC	—	.81	—	10.3	—		
8	S14	2896	1.72	1685	.32	538	10.3	5550		
9	S15	2869	.53	5420	.14	755	10.3	7390		
10	S16	DELETED	? A	[illegible]K	READING		SUBSTITUTED.			
11	S17	2057	1.42	1445	-3.20	4640	28.5	-132000		
12	S18	1029	NO RC.	—	—		28.5	NR.		
13	S19	2869	1.43	2010	.07	141	10.3	+1451		
14	S21	2896	1.34	2160	.06	129.5	10.7	+1385		
15	S22	2869	.33	8680	0	0	10.3	0		
16	S23	"	.81	3530	.07	247		+2540		
17	S26	"	1.54	1850	.22	406		4180		
18	S27	"	1.49	1920	.32	616		+6350		
19	S28	"	1.32	2170	.38	823		+8480		
20	S29	"	1.50	1910	.36	688		+7080		
21	S30	2896	.26	11100	.04	444		+4570		
22	S31	"	.36	8050	.06	483		+4980		
23	S32	"	1.80	1610	-.14	225		-2320		
24	S33	2869	1.60	1790	.14	251	10.3	+2590		

* The max. stress was estimated because at this instant the trace ran off oscillograph paper.

PREPARED BY JC

ALL-AMERICAN ENGINEERING CO.

CHECKED BY

DU PONT AIRPORT -- WILMINGTON, DELAWARE

MODEL NO.

DATE OCT 20 1962

RUN # 6 (135.6 KNOTS)

REPORT NO.

	Gh NO	K	$D_R = R_C$	$F_Z = K/D_R$	ΔD	$\epsilon \times 10^{+6}$ $F_Z(\Delta D)$	$E \times 10^{-6}$	S
1	S7	2910	1.58	1850	.67	1240	29.0	36000
2	S8	2869	1.82	1575	± .35	352	10.5	±3700
3	S9	2869	.42	6680	0	0	10.5	0
4	S10	2869	1.64	1770	-.77	-1362	10.3	-14020
5	S11	2869	1.65	1850	.58	1072		11030
6	S12	2869	1.8	1595	.55	876		9300
7	S13	2896	1.45	1995	.58	1158		11920
8	S14	2876	1.72	1685	.38	641		6620
9	S15	2869	.53	5420	.17	920	10.3	9500
10	S16	DELE			—	--	28.5	—
11	S17	2057	1.4	1445	-3.4	4920	28.5	-40000*
12	S18	1029	NO RC		NR	—	28.5	—
13	S19	2869	1.42	2020	.10	202	10.3	2080
14	S21	2896	1.32	2170	.09	195	[illegible]	2090
15	S22	2869	.33	8700	.02	173	[illegible]	1780
16	S23		.82	3510	.12	422		4340
17	S26		1.54	1862	.3	560		5760
18	S27		1.5	1915	.17	325		3350
19	S28		1.3	2210	.15	332		3420
20	S29	2869	1.47	1951	.34	664		6840
21	S30	2896	.27	10720	.07	752		7750
22	S31		.37	7840	-.14	-1095		-11300
23	S32	2896	1.77	1635	-.13	213		-2190
24	S33	2869	1.58	1815	.18	327	10.3	3370

* The max. stress was estimated because at this instant the trace ran off oscillagraph paper.

PREPARED BY JC

ALL-AMERICAN ENGINEERING CO.

PAGE 66

CHECKED BY

DU PONT AIRPORT -- WILMINGTON, DELAWARE

MODEL NO.

DATE OCT 21 1962

RUN #7 (78.4 KNOTS)

REPORT NO.

	GA NO	K	DR =Rc	F_z =K/DR	ΔD	ε $\times 10^6$ F_z(ΔD)	E $\times 10^{-6}$	S		
1	S7	2910	1.6	1850	.17	315	29	9150		
2	S8	2869	1.86	1575	.12	189	10.5	1990		
3	S9	2869	.37	6680	.0	0	10.5	0		
4	S10	2869	1.68	1770	-.2	353	10.3	-3640		
5	S11	2869	1.66	1850	.19	352		3620		
6	S12	2869	1.82	1595	.18	288		2970		
7	S13	2896	1.47	1995	.2	400		4130		
8	S14	2896	1.73	1685	.1	169		1750		
9	S15	2869	.54	5420	.06	327	10.3	3370		
10	S16		HOOK							
11	S17	2057	1.41	1445	-2.5	3620	28.5	-103,000	*	
12	S18	1029	N.R.							
13	S19	2869	1.45			0	10.3	0		
14	S21	2896	1.33			0	10.7	0		
15	S22	2869	.34		SMALL	0	10.3	0		
16	S23		.83			0		0		
17	S26		1.58			0		0		
18	S27		1.52	1890	-.1	189		+1960		
19	S28		1.35	2130	+.1	213		+2200		
20	S29	2869	1.52	1890	-.1	189		+[illegible]		
21	S30	2896	.28			0		0		
22	S31	2896	.38		SMALL	0		0		
23	S32	2896	1.82			0		0		
24	S33	2869	1.63			0	10.3	0		

* The max. stress was estimated because trace ran off oscillagraph paper.

PREPARED BY JC

ALL-AMERICAN ENGINEERING CO.

DU PONT AIRPORT -- WILMINGTON, DELAWARE

CHECKED BY

MODEL NO.

DATE OCT 21 1962 RUN # 8 (100.1 KNOTS)

REPORT NO.

	G	K	DR = RC	F2 = K/DR	ΔD	$\epsilon \times 10^{+6}$ F2 (ΔD)	$E \times 10^{-6}$	S		
1	S7	2910	1.6	1850	.36	6660	29	19320		
2	S8	2869	1.87	1575	.2	3150	10.5	3310		
3	S9	2869	.43	6680	0	0	10.5	0		
4	S10	2861	1.69	1770	-.44	-778	10.3	-8030		
5	S11	2869	1.68	1850	.35	647		6680		
6	S12	2869	1.82	1595	.28	446		4610		
7	S13	2896	1.48	1995	.4	797		8220		
8	S14	2896	1.75	1685	.23	387		3990		
9	S15	2861	.54	5420	.31	1680	10.3	17300		
10	S16		HOOK		[illegible]				*	
11	S17	2057	1.42	1445	-2.5		28.5	[illegible]		
12	S18		N.R							
13	S19	2869								
14	S21	2896								
15	S22	2869								
16	S23			NO	RECORD					
17	S26									
18	S27									
19	S28									
20	S29	2869								
21	S30	2896								
22	S31	2896								
23	S32	2896								
24	S33	2869								

* The max. stress was estimated because at this instant the trace ran off oscillagraph paper.

Run # 9 (116.2 kts)

G	K	$D_z = R_c$	$F_z = K/D_z$	ΔD	$\epsilon \times 10^6 = F_z(\Delta D)$	$E \times 10^{-6}$ psi	S
S7	2910	1.6	1850	.5	924	29	26800
S8	2869	1.86	1575	.25	394	10.5	4130
S9	"	.45	6390	0	0	10.5	0
S10	"	1.65	1770	−.57	1010	10.3	−10400
S11	"	1.65	1850	.46	852	"	8860
S12	"	1.82	1595	.42	670	"	6900
S13	2896	1.45	1995	.5	995	"	10280
S14	"	1.75	1685	.3	505	"	5200
S15	2869	.85	3390	.2	678	"	7000
S16	2057	Hook		—	—	—	—
S17	"	1.4	1445	−2.75	3880	28.5	−113500 *
S18	1029	N.R.	—	—	—	—	—
S19	2869	1.45	1980	.07	139	10.3	1415
S21	2896	1.34	2140	−.11	−235	10.7	−2510
S22	2869	.34	3450	0	0	10.3	0
S23	"	.83	3450	.04	138	"	1420
S26	"	1.57	1815	.23	417	"	4300
S27	"	1.51	1900	.35	665	"	6850
S28	"	1.31	2190	.32	700	"	7200
S29	"	1.52	1890	.32	632	"	6500
S30	2896	.27	10600	.06	635	"	6550
S31	"	.37	7850	−.12	−930	"	−9550
S32	"	1.78	1615	−.17	−276	"	−2850
S33	2869	1.60	1795	.24	430	"	4450

* The max. stress was estimated because the trace ran off oscillagraph.

PREPARED BY
CHECKED BY
DATE OCT 22 1962

ALL-AMERICAN ENGINEERING CO.

DU PONT AIRPORT -- WILMINGTON, DELAWARE

RUN #10 (130.2 KNOTS)

MODEL NO.
REPORT NO.

	G	K	D_R = RC	$F_2 = K/D_R$	ΔD	$\epsilon \times 10^6$ $F_2(\Delta D)$	E $\times 10^{-6}$	S		
1	S7	2910	1.56	1870	.62	1160	29	33,500		
2	S8	2869	1.83	156[illegible]	.34	530	10.5	5550		
3	S9		.42	6800	.01	68	10.5	711		
4	S10		1.63	1760	-.59	1040	10.3	-10,700		
5	S11		1.60	1792	.42	752		7750		
6	S12	2869	1.78	1610	.49	790		8100		
7	S13	2896	1.42	2040	.60	1220		12500		
8	S14	2896	1.71	1700	.35	594		6100		
9	S15	2869	.88	3250	.24	780	10.3	8050		
10	—									
11	S17	2057	.62	3340	-1.62	-5410	28.5	-155000		
12	S18	1029	N.R.							
13	S19	2869	1.45	1980	.12	238	10.3	2450		
14	S21	2896	1.35	2130	.08	171	10.7	1750		
15	S22	2869	.32	8950	0	0	10.3	0		
16	S23		.95	3010	.08	242		2500		
17	S26		1.58	1810	.25	452		4650		
18	S27		1.50	1910	.40	762		7850		
19	S34		.45	6410	.05	320		3300		
20	S28		1.30	2200	.42	922		9510		
21	S29	2869	1.50	1910	.38	725		7450		
22	S30	[illegible]	.25	11600	.10	1160		12000		
23	S31	2896	.36	8010	-.02	160		-1650		
24	S32	2896	1.75	1660	-.15	249	10.3	-2560		
25	S33	2801	1.60	1790	.22	344	10.3	4050		
26	S35	2869	.59	4800	0		10.3	0		

PREPARED BY ________ **ALL-AMERICAN ENGINEERING CO.** PAGE 70

CHECKED BY ________ DU PONT AIRPORT - WILMINGTON, DELAWARE MODEL NO. ________

DATE ________ Eur. #10a (Braking) 175,000# G.W. REPORT NO. ________

G	$K \times 10^6$	R_c	F_2	ΔD	ϵ	$E \times 10^{-6}$	S_{psi}		
S7	2910	1.58		-.05		29	-4350		
S8	2869	1.83		.10		12.5	1640		
S9	"	.42		.04		10.3	2860		
S10	"	1.63		.13		"	2350		
S11	"	1.66		-.47			-3580		
S12	"	1.80		-.43			-7120		
S13	2896	1.45		-.52			-12000		
S14	2896	1.72		-.23			-4050		
S15	2869	.83		-.20		10.3	-6700		
S17	2057	.63		0		28.5	0		
S16	Not	hooked	Up				—		
S19	2869	1.40	2050	-.01		10.3	-20[illegible]		
S21	2896	1.35	2130	[illegible]		10.7	1135		
S22	2869	.32	9950	.02		10.3	1840		
S23	"	.80	3580	.02		"	72[illegible]		
S26		1.45	1970	-.16			-15[illegible]		
S27	"	1.50	1910	-.38		"	-7490		
S34	"	.50	5720	-.01		"	-593		
S28	"	1.30	2200	-.36		"	-3170		
S29	2869	1.48	1910	-.33		"	-7480		
S30	2896	.28	11600	-.02		"	[illegible]		
S31	"	.35	8010	-.13		"	-10700		
S32	"	1.80	1610	-.41		"	-6310		
S33	2869	1.60	1790	-.35		"	-[illegible]480		
S35	2869	.53	5470	+.06		10.3	3380		

PREPARED BY

CHECKED BY

DATE

ALL-AMERICAN ENGINEERING CO.

DU PONT AIRPORT -- WILMINGTON, DELAWARE

Run #11

PAGE 71

MODEL NO.

REPORT NO.

G	K×10	R_c	F_z	ΔD	ε	$E \times 10^6$	S psi		
S7	2910	1.56	1870	.4		29	21,700		
S8	2869	1.82	1560	.12		10	1970		
S9	"	.42	6300	0		10.5	0		
S10	"	1.62	1760	-.45		103	-8200		
S11	"	1.65	1730	.35			6780		
S12	"	1.77	[illegible]	.33		'	5510		
S13	2876	1.43	2040	.42		"	3820		
S14		1.70	1700	.55		'	4270		
S15	2869	.87	3250	.63		103	7700		
S17	2057	.63	3340	-1.1		235	-105000		
S18	1029	.62	1660	-1.12		235	[illegible]		
S19	2869	1.4		0			0		
S21	2896	1.32		0			0		
S22	2869	.33		0			0		
S23		.80		0			0		
S26		1.45		.09			1540		
S27	'	1.58		-.15			-2960		
S34	'	.54		0			0		
S28	'	1.26		+.11			2570		
S29	2861	1.45		+.11			2250		
S30	2896	.25		0			0		
S31	"	.35		0			0		
S32	"	1.72		-.20			-3430		
S33	2869	1.58		.13			2400		
S35	2869	.58		0			0		

PREPARED BY JC

CHECKED BY

DATE OCT 24 62

ALL-AMERICAN ENGINEERING CO.

DU PONT AIRPORT - WILMINGTON, DELAWARE

(101.1 KNOTS) RUN #12

PAGE 72

MODEL NO.

REPORT NO.

	G	K	Rc	F2	ΔD	ε ×10⁻⁶	E ×10⁻⁶	S		
1	S7		1.57	1870	.53	992	29	28800		
2	S8		1.82	1560	.18	281	10.5	2950		
3	S9		.42	6800	0		10.5	0		
4	S10		1.63	1760	-.60	-1055	10.3	-10900		
5	S11	2869	1.64	1750	.47	823	↑	8500		
6	S12		1.77	1610	.38	612		6320		
7	S13		1.44	2040	.48	980		10100		
8	S14		1.70	1700	.30	510		5250		
9	S15		.87	3250	.22	715	↓	7350		
10							10.3			
11	S17		.62	3340	-.92	-3070	28.5	-87500		
12	S18	1029	.47	2200	-.75	-1650	28.5	-46100		
13	S19	286[illegible]	1.40	2040	+.0[illegible]	163	10.3	1690		
14	S21	28[illegible]	1.35	2130	0	0	10.7	0		
15	S22	2869	.35	8950	0	0	10.3	0		
16	S23	2869	.5	5740	0	0	↑	0		
17	S26	2869	1.52	1890	+.[illegible]	278		2870		
18	S27	2869	1.58	1910	+.39	745		7680		
19	S34	2869	.5	5740	[illegible]	115		1290		
20	S28	2869	1.25	2270	.3	680		7010		
21	S29	2869	1.45	193[illegible]	+.31	613		6350		
22	S30	289[illegible]	.39	7450	0	0		0		
23	S31	2896	.32	8010	-.15	-120		-1240		
24	S32	2896	1.75	1660	-.2	-332		-3320		
25	S33	2869	1.58	1790	+.[illegible]	-215	↓	+2220		
26	S35	2869	.58	4800	-.01	-48	10.3	-496		

PREPARED BY ________ **ALL-AMERICAN ENGINEERING CO.** PAGE 73

CHECKED BY ________ DU PONT AIRPORT - WILMINGTON, DELAWARE MODEL NO. ________

DATE Oct 22, 1962 Run #13 (114.7 knots) REPORT NO. ________

	G	$K \cdot 10^6$	$D_R = R_c$	$F_z = K/D_R$	ΔD	$\epsilon \times 10^6 = F_z(\Delta D)$	$E \times 10^{-6}$	S psi
1	S7		1.55	1870	.72			39200
2	S8		1.82	1560	.18			2950
3	S9		.42	6800	0			0
4	S10		1.62	1760	-.83			-15100
5	S11		1.63	1750	.60			10900
6	S12		1.78	1610	.55			9150
7	S13		1.42	2040	.42			8850
8	S14		1.68	1700	.41			7200
9	S15		.87	3250	.24			8020
10	—							
11	S17		.62	3340	-.88	-2930	28.5	-83500
12	S18		.47	2200	-.95	-2090	28.5	-59500
13	S19	2867	1.42	2020	.08	162	10.3	1670
14	S21	2896	1.3	2310	.02	46.2	10.7	4620
15	S22	2569	.48	5980	0	0	10.3	0
16	S23	2869	.58	4950	0	0	↑	0
17	S26	2869	1.51	1890	.28	528		5450
18	S27	↑	1.58	1910	.45	860		8880
19	S34		.60	4780	.02	95.8		990
20	S28	↓	1.25	2270	.38	863		8900
21	S29	2869	1.50	1910	.39	745		8680
22	S30	2896	.80	3730	.09	337		3470
23	S31	2896	.70	4260	-.32	1362		-14050
24	S32	2896	.74	4040	-.19	835		-8600
25	S33	2869	1.58	1815	+.19	345	↓	3550
26	S35	2867	.8	3590	0	0	10.3	0

PREPARED BY

CHECKED BY

DATE Oct 24, 1962

ALL-AMERICAN ENGINEERING CO.

DU PONT AIRPORT - WILMINGTON, DELAWARE

PAGE 74

MODEL NO.

REPORT NO.

Run # 14 (123.0 KTS)

	G	K	Rc	Fz	ΔD	ε	Σ	S
1	S7	2910	1.54	1870	.77		29	42000
2	S8	2869	1.78	1610	.23	371	10.7	4050
3	S9	2869	.64	4460	0		10.7	0
4	S10	"	1.60	1760	-.88			-16,000
5	S11	"	1.62	1750	.69			12,500
6	S12	2869	1.65	1740	.58	1010	10.3	10400
7	S13	2896	1.40	2040	.70			14800
8	S14	"	1.65	1700	.47			3250
9	S15	2869	.85	3250	.34			11400
10								
11	S17	2057	.62	3340	-.85		28.5	-80,500
12	S18	1029	.45	2200	-.85		28.5	-53,800
13	S19	2869	1.4	2020	.12		10.3	2500
14	S21	2896	1.3	2310	0		10.7	0
15	S22	2869	.62	4630	.02		10.3	9550
16	S23	"	.78	3680	.03			11350
17	S26	"	1.42	2020	.31			6470
18	S27		1.55	1850	.52			7130
19	S34	"	.61	4710	.08			3880
20	S28	"	1.22	2350	.48		"	11650
21	S29	"	1.50	1915	.49		"	9610
22	S30	2896	.90	3330	.19		"	6530
23	S31	"	.90	3330	-.40		"	-13700
24	S32	"	1.75	1710	-.15		"	-2650
25	S33	2869	1.58	1892	+.22		"	4280
26	S35	2869	.80	3750	.06		"	2320

PREPARED BY

ALL-AMERICAN ENGINEERING CO.

CHECKED BY

DU PONT AIRPORT - WILMINGTON, DELAWARE

MODEL NO.

DATE Oct. 25, 1962 RUN #15 (V= 29.8 KTS)

REPORT NO.

	G	K	R_c	F_z	ΔD	ϵ	E	S		
1	S7	2910	1.56		.90		29	48800		
2	S8	2869	1.80	1600	.24	385	10.7	4100		
3	S9		.65		0		10.7	0		
4	S10		1.60		-1.06		10.3	-19600		
5	S11		1.62		.72			13200		
6	S12		1.66		.60			12500		
7	S13	2896	1.42		.76			16000		
8	S14	2896	1.68		.48			8520		
9	S15	2869	.87		.31			10600		
10										
11	S17	2057	.62		-.94		28.5	-89500		
12	S18	1029	.47		-1.16		28.5	-72000		
	S19	2869	1.4		.11		10.3	2290		
	S21	2896	1.3		-.02		10.7	4950		
	S22	2869	.62		0		10.3	0		
	S23	"	.79		0		"	0		
	S26	"	1.4		.3		"	6250		
	S27	"	1.55		.57		"	10900		
	S34	"	.62		.04		"	1940		
	S28	"	1.22		.48		"	11650		
	S29	"	1.52		.51		"	10150		
	S30	2896	.92		.12		"	4120		
	S31	"	.89		-.49		"	-16800		
	S32	"	1.75		-.27		"	-1492		
	S33	2869	1.58		.2		"	3900		
	S35	2869	.90		.02		"	660		

PREPARED BY ______

CHECKED BY ______

DATE Oct 26, 1962

ALL-AMERICAN ENGINEERING CO.

DU PONT AIRPORT - WILMINGTON, DELAWARE

Run #16 (1[illegible].5 KTS) 20' off center

PAGE 76

MODEL NO. ______

REPORT NO. ______

	G	K	R_2	F_2	ΔD	ϵ	E	S
1	S7	291[illegible]	1.[illegible]	1920	.25	480	29	13900
	S8	[illegible]	1.76		.15		10.7	2620
	S9		.65		0		10.3	0
	S10		1.5[illegible]		-.38		"	-7100
	S11		1.60		.36			6620
	S12		1.62		.28		'	51[illegible]
	S1[illegible]	281.	[illegible].33		.37		'	8000
	[illegible]		1.6[illegible]		.20		'	36[illegible]
	S1[illegible]	2[illegible]	.67		.19		10.3	+6450
	[illegible]	[illegible]	.62	[illegible]330	-.95	216[illegible]	28.5	-1[illegible]
	S1[illegible]	1029	.46	2240	-.95	2130	28.5	-60,000
12	S1[illegible]	[illegible]	1.40		.05		10.3	1055
	S21	2[illegible]1[illegible]	1.30		0		10.7	0
5	S2[illegible]	2[illegible]6[illegible]	.62		0		10.3	0
	S2[illegible]	'	.79		.05			2000
	S2[illegible]	'	1.40		.10			2120
	S27		1.55		.17			3240
	S34		.62	4[illegible]3[illegible]	.05	[illegible]32	[illegible]	[illegible]
	S2[illegible]	'	1.22		.22		"	+5350
21	S29				0		"	+ 0
22	S30	239[illegible]	.92		.03		'	+975
✓23	S31	"	.89	[illegible]	-.3[illegible]	1230	1[illegible]	+12,70[illegible]
24	S3[illegible]	"	1.70		-.20		'	-3540
[illegible]	S32	2561	1.[illegible]		.15		'	+2880
2[illegible]	S3[illegible]	'	.82	3490	-.04	140	10.3	-1440

PREPARED BY

CHECKED BY

DATE [illegible]

ALL-AMERICAN ENGINEERING CO.

DU PONT AIRPORT - WILMINGTON, DELAWARE

Run #17 (104.2 Hg) 2 [illegible]

MODEL NO.

REPORT NO.

G	K	R_c	F_2	ΔD	ϵ	E	S		
S7	2910	1.[illegible]		.57		29	31600		
S[illegible]	2[illegible]	1.76		.19		[illegible]	3320		
[illegible]	"	.14		0		10.7	0		
[illegible]	"	1.[illegible]		-.65		[illegible]	+12100		
S1[illegible]	"	1.6[illegible]		.50		"	9200		
S12		1.62		.45		"	8220		
S1[illegible]	28[illegible]	1.3[illegible]		.50		"	10900		
S14	"	1.64		.[illegible]		"	6[illegible]00		
S15	2[illegible]	.87		.27		"	9[illegible]		
S1[illegible]	2057	.[illegible]2		-.90		28.5	-85200		
S18	1029	.46		[illegible].22		28.5	-7[illegible]		
S19	2[illegible]	1.35		.12		1[illegible]	2580		
S2[illegible]	28[illegible]	1.3[illegible]		.07		10.[illegible]	1690		
S22	2861	.6[illegible]		0		1[illegible]	0		
S23		.77		0			0		
S26		1.40		.25			5300		
S27		1.52		.36			74[illegible]		
S24	2561	.6[illegible]		.[illegible]		10.3	990		
S28		1.22		.35			8500		
S2[illegible]	"	.5[illegible]		.15			[illegible]150		
S30	25[illegible]	.90		+.10			+3410		
S31	2896	.32		-.35			-11900		
S32	2[illegible]	1.70		-.21			-[illegible]700		
S33	28[illegible]	[illegible]		+.18			+ —		
S35	2[illegible]1	.52		.05		10.3	1800		

PREPARED BY ____________ **ALL-AMERICAN ENGINEERING CO.** PAGE 78

CHECKED BY ____________ DU PONT AIRPORT - WILMINGTON, DELAWARE MODEL NO. ____________

DATE Oct. 26, 1962 Run #18 (121.0 kts) 20' off center REPORT NO. ____________

G	K	R_c	F_z	ΔD	ϵ	E	S		
S7	2910	1.52		.68		29	37700		
S8	2860	1.76		.20		10.7	3500		
S9		.65		0		10.7	0		
S10		1.56		-.80		10.3	-15000		
S11		1.66		.57			10500		
S12		1.62		.50			9150		
S13	2870	1.39		.63			12500		
S14		1.66		.40			7200		
S15		.85		.27			9500		
S17	2057	.62		-1.0		28.5	-15000		
S18	1029	.46		-.92		28.5	-5000		
S19	2869	1.31		.06		1.3	1710		
S21	2896	1.30		.05			1170		
S22	2881	.62		0			0		
S23	"	.77		0			0		
S26	"	1.43		.17			3580		
S27		1.53		.27			[illegible]		
S34		.50		-.08			-3980		
S28		1.33		+.40			+9600		
S29		.49		+.11			+[illegible]		
S30	2890	.90		+.10			+3320		
S31		.88		-.50			-17000		
S32		1.72		-.28			-4870		
S33	2869	1.55		+.20			+3520		
S35		.89		.06			2150		

PREPARED BY________ **ALL-AMERICAN ENGINEERING CO.** PAGE 79

CHECKED BY________ DU PONT AIRPORT - WILMINGTON, DELAWARE MODEL NO.________

DATE Oct 27, 1952 Run #19 (79.5KTS) 40' aft [illegible] REPORT NO.________

	G	K	[illegible]	F_z	ΔD	[illegible]	E	S		
	[illegible]	[illegible]	1.52		.31		29	17200		
	[illegible]	286[illegible]	1.7[illegible]		.1[illegible]		10.7	1670		
	[illegible]	"	.6[illegible]		0		10.[illegible]	0		
	[illegible]		1.[illegible]		-.35		[illegible]	-6900		
	S11		1.60		.36			6620		
	S12		1.62		.3[illegible]			[illegible]		
	S13	2816	1.31		.37			7320		
	S14		1.67		.21			[illegible]700		
	S[illegible]		.85		.1[illegible]			6330		
	S17	2057	.61		-1.0		[illegible]	-[illegible]400		
	S18	1029	.46		-.96		28[illegible]	-[illegible]700		
	[illegible]	2867	1.40		[illegible]		[illegible]3	1070		
	[illegible]	251[illegible]	[illegible]		[illegible]		11.7	0		
	[illegible]	289[illegible]	.[illegible]		[illegible]		10.[illegible]	0		
	S22		.78		.05			1700		
	S2[illegible]		1.1[illegible]		.12			2500		
	S2[illegible]		[illegible]		.20			2560		
	S24		.60		0			0		
20	S28		1.[illegible]		+.23			+5550		
21	S29		.5[illegible]		0			0		
22	S30	2916	.91		.03			985		
23	S31		.[illegible]		-.15			-[illegible]080		
24	S32		1.72		-.20			-[illegible]480		
25	S33	23[illegible]	1.55		+.16			+3050		
	S35		.83		.05			1750		

PREPARED BY ____ | **ALL-AMERICAN ENGINEERING CO.** | PAGE 80

CHECKED BY ____ | DU PONT AIRPORT - WILMINGTON, DELAWARE | MODEL NO. ____

DATE [illegible] | [illegible] 102.4 [illegible] | REPORT NO. ____

[illegible]	K	R_c	F_z	ΔT	ϵ	E	S		
[illegible]	[illegible]			[illegible]		29	[illegible]1400		
[illegible]	[illegible]	[illegible]		.17		[illegible]	[illegible]170		
[illegible]		[illegible]		0		[illegible]	C		
[illegible]		[illegible]		-[illegible]		[illegible]	-11950		
S11		[illegible]		[illegible]			9260		
[illegible]		[illegible]		.42			[illegible]		
[illegible]		[illegible]		.52			11200		
[illegible]		[illegible]		[illegible]			[illegible]		
S15		[illegible]		[illegible]			[illegible]10		
S[illegible]	[illegible]	.41		[illegible].0[illegible]		[illegible]	-[illegible]		
[illegible]	[illegible]	[illegible]		-[illegible]		[illegible]	-[illegible]		
S1	[illegible]	[illegible]		[illegible]		[illegible]	1055		
[illegible]	241.	[illegible]		[illegible]		[illegible]	0		
S2[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	0		
S2[illegible]		.18		-[illegible]			-[illegible]		
[illegible]		[illegible]		[illegible]			[illegible]		
[illegible]		[illegible]		-[illegible]			-[illegible]		
[illegible]		[illegible]		.07			34[illegible]		
S2[illegible]		[illegible]		.1[illegible]			[illegible]		
S2[illegible]		[illegible]		[illegible]			4[illegible]		
S3[illegible]	[illegible]	[illegible]		+.[illegible]			+[illegible]		
S31		[illegible]		-.[illegible]			-3170		
[illegible]		[illegible]		-[illegible]			-2[illegible]		
S3[illegible]	24[illegible]	1.[illegible]		-.[illegible]			+[illegible]		
S35		[illegible]		[illegible]			175[illegible]		

PREPARED BY

CHECKED BY

DATE [illegible]

ALL-AMERICAN ENGINEERING CO.

DU PONT AIRPORT - WILMINGTON, DELAWARE

[illegible] (27.4)

PAGE 31

MODEL NO.

REPORT NO.

[illegible]	[illegible]	[illegible]	[illegible]	ΔD	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]		.31		[illegible]	3540		
[illegible]		[illegible]		0		[illegible]	0		
[illegible]		[illegible]		[illegible]		[illegible]	[illegible]		
[illegible]		[illegible]		[illegible]			[illegible]		
[illegible]				[illegible]			[illegible]		
[illegible]	[illegible]	[illegible]		.35			[illegible]400		
[illegible]		[illegible]					[illegible]		
[illegible]		[illegible]					2000		
[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]		-.63		[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]		[illegible]		[illegible]			
[illegible]	[illegible]	[illegible]				[illegible]	[illegible]		
[illegible]		[illegible]		[illegible]					
[illegible]		[illegible]					[illegible]		
[illegible]				[illegible]			[illegible]		
[illegible]		[illegible]		[illegible]			[illegible]		
[illegible]		[illegible]		[illegible]		[illegible]	[illegible]		
[illegible]		[illegible]		.15			[illegible]		
[illegible]	[illegible]	[illegible]		+.12		[illegible]	+[illegible]40		
[illegible]		[illegible]		[illegible]		[illegible]	[illegible]		
[illegible]				[illegible]			-[illegible]580		
[illegible]	[illegible]	[illegible]		.29			5300		
[illegible]		[illegible]		-.1			[illegible]		

PREPARED BY

CHECKED BY

DATE Oct. 22, 1962

ALL-AMERICAN ENGINEERING CO.

DU PONT AIRPORT - WILMINGTON, DELAWARE

MODEL NO.

REPORT NO.

Ru #22 (94.0 [illegible]) [illegible]

G	K	R_c	F_z	ΔD	∈	E	S		
[illegible]	2910	[illegible]		.45		29	25000		
[illegible]	2869	1.5[illegible]		.15		10.7	2560		
	"	[illegible]		0		10.7	0		
S1[illegible]	"	[illegible]		-.[illegible]		10.3	-9450		
S11	"	1.6[illegible]		.35			7030		
S1[illegible]	"	1.65		.5[illegible]			5360		
S1[illegible]	2896	[illegible]		.4[illegible]			8530		
S14	"	1.67		.22			3930		
S[illegible]	"	.67		[illegible]			6520		
[illegible]	2057	N.G. Da[illegible]		[illegible]		28.5	—		
S18	1:29	.23		-.6[illegible]		24.5	-[illegible]50		
[illegible]	2869	.4[illegible]		.05		10.3	1057		
[illegible]	2896	[illegible]		.05		10.7	1150		
S2[illegible]	2869	[illegible]				10.3	0		
S[illegible]	"	.78		0			0		
S2[illegible]	"	1.42		.18			3760		
S2[illegible]	"	1.55		.28			5350		
S3[illegible]	"	.60		.05			2470		
S2[illegible]	"	.25		.25			5900		
S2[illegible]	"	[illegible]		.15			8860		
S3[illegible]	2896	.91		.08			2630		
S3[illegible]	"	.96		-.26			-8640		
S3[illegible]	"	1.72		-.27			-4700		
S[illegible]	2869	1.56		+.12			+2280		
S3	"	.83		-.0[illegible]			-2850		

S17 deleted

PREPARED BY	ALL-AMERICAN ENGINEERING CO.	PAGE 93
CHECKED BY	DU PONT AIRPORT - WILMINGTON, DELAWARE	MODEL NO.
DATE	(106.3 KTS) 60' off [illegible]	REPORT NO.

[illegible]	[illegible]	R_c	ΔP	[illegible]	[illegible]	[illegible]			
	2[illegible]	1.52	.59		29	322[illegible]			
	2[illegible]	[illegible]	.16		10.7	3070			
		[illegible]	0		[illegible]	0			
		1.[illegible]	-.45		[illegible]	-5320			
		1.6[illegible]	[illegible]			[illegible]			
		1.6[illegible]	.42			7520			
	2[illegible]	1.4[illegible]	.56			11950			
		1.67	.32			5730			
		.67	.27			4260			
	2[illegible]	N.G.							
	10[illegible]	.33	-.62		29.[illegible]	-[illegible]			
	[illegible]	1.40	.1[illegible]		10.3	360			
	28[illegible]	1.30	-.[illegible]		10.7	-132			
	2[illegible]	.62	0		[illegible]	0			
		.78	0			0			
		1.42	.27			5620			
		1.35	.39			7440			
		.60	-.07			-3440			
		1.25	.38			8970			
		.50	.11			[illegible]20			
	28[illegible]	.90	.11			3650			
		.90	-.21			-[illegible]			
		1.72	-.35			-6080			
	28[illegible]	1.56	.15			2850			
	"	.83	-.07			-2500			

PREPARED BY

CHECKED BY

DATE Oct. 22, 1962

ALL-AMERICAN ENGINEERING CO.

DU PONT AIRPORT - WILMINGTON, DELAWARE

Run #24 (115.4 kts) 60' off Center

MODEL NO.

REPORT NO.

S17 deleted

G	K	Rc	F	ΔD	C	E	S		
S7	2910	[illegible]		.65		[illegible]	36100		
S8	2869	[illegible]		.18		[illegible]	3070		
S9		.65		0		[illegible]	0		
S10		1.62	1770	-.35	6200	[illegible]	-6380		
S11		[illegible]	1792	.55			10150		
S12	2869	[illegible]	1740	.50			8950		
S13	2896	1.45	2060	.58			12400		
S14		1.68	1720	.37			6630		
S15	2896	.87	3320	.29			9950		
S16		N.G.		N.G		28.5	N.G.		
S18	1029	.33		-.65		[illegible]	[illegible]		
S19	2869	1.40		.10		10.3	2110		
S21	2896	1.30		.65		10.7	1192		
S22	2869	.62		0		[illegible]	0		
S23	2869	.78		0			0		
S26		1.42		.30			6250		
S27		1.55		.32			6100		
S34		[illegible]		[illegible]			[illegible]		
S28		1.27		.38			8820		
S29	2869	.50		.15			[illegible]		
S30	2896	.90		.12			3980		
S31		.90		-.35			-11620		
S32	2896	1.75	1652	-.32	-532		-5420		
S33	2869	[illegible]	1855	.21	3900		4020		
[illegible]	[illegible]	.37		[illegible]			[illegible]		

PREPARED BY

CHECKED BY

DATE OCT 25 1962

ALL-AMERICAN ENGINEERING CO.

DU PONT AIRPORT - WILMINGTON, DELAWARE

[illegible] V=126.0 kts)

PAGE 85

MODEL NO.

REPORT NO.

	[illegible]	K	[illegible]	F_2	AD	C	F	S		
1	[illegible]	7			+.82			45600		
2	[illegible]				+.1		+	1700		
3	[illegible]			4420	+.05	-221	10.7 +	2360		
4	S1[illegible]				+.15			2740		
5	[illegible]				+.05		+	9150		
6					+.22			3940		
7	[illegible]				+.55			11750		
8	[illegible]				+.4			7180		
9	[illegible]				+.3			10300		
10					—					
11	S[illegible]	DELETED			—					
12	[illegible]	10[illegible]	.33		-.7			-62400		
13	[illegible]				+.1			2110		
14	[illegible]				+.02		+	478		
15	[illegible]				0			0		
16	S[illegible]				0			0		
17	[illegible]				.32			6670		
18	[illegible]				.5			9530		
19	S3[illegible]		[illegible]		.02			938		
20	S[illegible]				.45			10450		
21	S2[illegible]				.2			11850		
22	[illegible]				.1			3320		
23	S31				-.1			-3330		
24	S3[illegible]				-.2			-33[illegible]0		
25	[illegible]				.2			4020		
26	[illegible]		.33		0			0		

PREPARED BY JC

ALL-AMERICAN ENGINEERING CO.

PAGE 86

CHECKED BY

DU PONT AIRPORT - WILMINGTON, DELAWARE

MODEL NO.

DATE OCT 29 1940

RUN #26 (Y = 116.0 KNOTS) WET RUNWAY (40'0.C)

REPORT NO.

	G	K	Rc	F_2	ΔD	∈	E	S		
1	S7	2910	1.54		.63			33[illegible]		
2	S8	2869	1.80		+.1			+1710		
3	S9	↑	.65		0			0		
4	S10		1.60		+.15			2740		
5	S11	↓	1.60		-.32			-5920		
[illegible]	S12	2869	1.63		+.51			4300		
7	S13	2896	1.40		+.58			12400		
8	S14	↕	1.67		+.38			6630		
* 9	S15	2896	.87		+.30			9950		
10	S16	HOOK	NO RC					—		
11	S17	2910*	.42	6830	-.45			-87700		
12	S18	1027	.32		-.52			-47700		
13	S19	2869	1.42		+.08			1660		
14	S21	2896	1.31		0			0		
15	S22	2869	.63		0			0		
16	S23	2869	.79		-.05			1870		
17	S26	↑	1.43		+.32			2650		
** 18	S27		1.57		+.45			8580		
19	S34		.62		0			0		
20	S28	↓	1.25		+.42			9900		
21	S29	2869	.50		+.15			8870		
22	S30	2896	.91		+.1			3900		
23	S31	↕	.91		-.28			-9320		
24	S32	2896	1.75		-.32			-5420		
25	S33	2869	1.58		+.21			4020		
** 26	S35	2869	.81		0			0		

PREPARED BY JC

CHECKED BY

DATE OCT 29 1962

ALL-AMERICAN ENGINEERING CO.

DU PONT AIRPORT — WILMINGTON, DELAWARE

RUN #27 (V = 123.2 Kts) 20' O.C.

MODEL NO.

REPORT NO.

	G	K	RC	FZ	ΔD	ϵ	E	S		
1	S7	2910			+.8			42800		
2	S8	2869			−.15			−2560		
3	S1				0			0		
4	S10				.1			1830		
5	S11				−.35			−6460		
6	S12	2869			+.5			9300		
7	S13	2896			+.22			−4700		
8	S14				+.22			−4880		
9	S15	2896			.20			6630		
10	S6	HOOK		NO	[illegible]					
11	S7	2910			−.80			−156000		
12	S18	1029			−.75			− 68800		
13	S19	2869	1.42		+.15			3110		
14	S21	2896	1.31	2210	+.06			+1328		
15	S22	[illegible]	.63		0			0		
16	S23	2869	.79		0			0		
17	S26		1.43		+.3			6250		
18	S27		1.57		.45			8580		
19	S34		.62		0			0		
20	S28		1.25		.35			8250		
21	S29	2869	.50	5750	.13	748		[illegible]		
22	S30	2896	.91		.1			3900		
23	S31	[illegible]	.91		−.[illegible]			− 5930		
24	S32	[illegible]	1.75		−.[illegible]			− 5420		
25	S33	2869	1.58		+.15			2870		
26	S35	2869	.81		0			0		

PREPARED BY JC

CHECKED BY

DATE OCT 30 1962 RUN #28 (96.4 kts)

ALL-AMERICAN ENGINEERING CO.

DU PONT AIRPORT - WILMINGTON, DELAWARE

PAGE 33

MODEL NO.

REPORT NO.

	G	K	Rc	Fz	ΔD	ε	E	S		
1	S7				.12			6430		
2	S8				0			0		
3	S9				0			0		
4	S10				+.22		+	4030		
5	S11				−.2			−3700		
6	S12				.2			3740		
7	S13				.2			4600		
8	S14				.13			2270		
9	S15				.1			3315		
10	S16				0		NO	RC.		
11	S17	2910	.70.	4170	−1.0		[illegible] −	119000		
12	S18				−.82		−	75300		
13	S19				.05			1040		
14	S21				.02			442		
15	S22				0			0		
16	S23				0			0		
17	S26				0			0		
18	S27				+.1		+	1910		
19	S34				0			0		
20	S28				±.1			3360		
21	S29			^				~~0~~		
22	S30				−.02			0		
23	S31				−			0		
24	S32				−.15		−	3540		
25	S33				+.1		+	1910		
26	S35				0			0		

GPO 944066